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INDIVIDUAL DIFFERENCES IN LEARNING FROM SELF-PACED PROGRAMED INSTRUCTION, REPORT 1--STUDIES IN TELEVISED INSTRUCTION, INDIVIDUALIZING GROUP INSTRUCTION.

BY- GROPPER, GEORGE L. KRESS, GERARD C., JR.

METROPOLITAN PITTSBURGH EDUC. TV STATION, PA.

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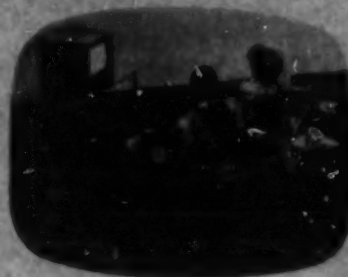
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SELF-PACED INSTRUCTION, DETERMINANTS OF A SELF-ADOPTED PACE, AND THE EFFECTS OF THE PACE ADOPTED ON BEHAVIOR WERE STUDIED. THIS REPRESENTED THE FIRST IN A SERIES OF THREE STUDIES, CONCERNING THE RELATIONSHIP BETWEEN PACING MODE AND BEHAVIOR. (REFER TO ACCESSION NUMBERS ED 003 200, ED 003 201, AND ED 003 202 FOR ADDITIONAL INFORMATION ON THIS PROJECT). TWO SELF-PACED SCIENCE PROGRAMS WERE ADMINISTERED TO 2 SEPARATE EIGHTH-GRADE GROUPS OF APPROXIMATELY 250 AND 360 STUDENTS. BOTH PROGRAMS WERE PRESENTED THROUGH SLIDES AND TELEVISION. PRINCIPAL ABILITY MEASURES OBTAINED WERE INTELLIGENCE AND READING COMPREHENSION. PERFORMANCE MEASURES FOR EACH PROGRAM WERE PRETEST SCORES, PROGRAM COMPLETION TIMES, ERROR NUMBERS, AND POST-TEST SCORES. RESULTS WERE DISCUSSED WITH RESPECT TO PREDICTORS OF WORK RATE, PREDICTORS OF ERRORS, AND PREDICTORS OF ACHIEVEMENT. MANY STUDENTS EXHIBITED CHARACTERISTIC WORK HABITS, REFLECTING A CONSISTENCY OF THE PACE THEY ADOPTED AND OF THE FREQUENCY OF ERRORS COMMITTED. NEITHER CONSISTENT PATTERN WAS PREDICTED BY MEASURES OF ABILITY. THE WISDOM OF ALLOWING ALL STUDENTS TO PACE THEMSELVES WAS QUESTIONED. RECOMMENDATIONS WERE MADE FOR FURTHER INVESTIGATIONS TO DETERMINE WHETHER (1) EXTERNAL CONTROL OVER A STUDENT'S RATE OF WORK IMPROVES PERFORMANCE (IF HE WORKS AT AN INAPPROPRIATE RATE IN SELF-INSTRUCTION) AND (2) THE RESPONSES A STUDENT MAKES AS A CONSEQUENCE OF HIS ERRORS SHOULD BE GUIDED SO THAT ACHIEVEMENT MAY BE IMPROVED. (JC)

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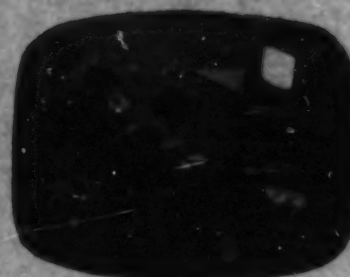
STUDIES IN
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INDIVIDUALIZING
GROUP
INSTRUCTION



1. INDIVIDUAL DIFFERENCES IN LEARNING FROM SELF-PACED PROGRAMMED INSTRUCTION

Gerard C. Kress Jr.
and
George L. Gropper

METROPOLITAN PITTSBURGH EDUCATIONAL TELEVISION STATION
and the AMERICAN INSTITUTES FOR RESEARCH

The research reported herein was conducted under the direction of George L. Gropper, Principal Investigator, and was supported by a grant from the U.S. Department of Health, Education, and Welfare Office of Education, Title VII, Project Number 637, National Defense Education Act of 1958 Grant Number 7-36-120-01

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STUDIES IN TELEVISED INSTRUCTION

individualized group instruction

Report #1 - Individual differences in learning from self-paced programmed instruction.

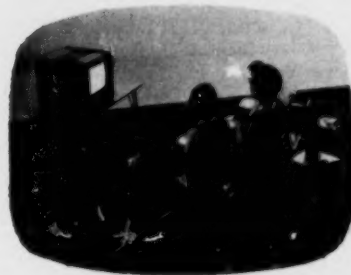
Report #2 - The influence of external pacing on learning from programmed instruction.

Report #3 - Accommodating individual differences during externally-paced programmed instruction.

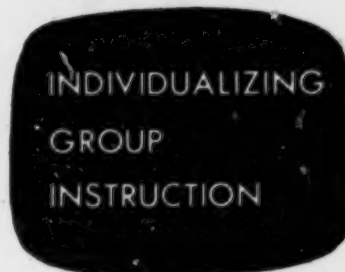
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**STUDIES IN
TELEVISED
INSTRUCTION**



**1. INDIVIDUAL DIFFERENCES
IN LEARNING FROM SELF-PACED
PROGRAMMED INSTRUCTION**

**Gerard C. Kress, Jr., Project Director
and
George L. Gropper, Principal Investigator**

NOVEMBER 1964

**METROPOLITAN PITTSBURGH EDUCATIONAL TELEVISION STATION
and the AMERICAN INSTITUTES FOR RESEARCH**

FOREWORD

The research reported in this volume was conducted under a grant from the U. S. Department of Health, Education, and Welfare, Office of Education, under title VII, the National Defense Education Act of 1958, Project No. 637, Grant No. 7-36-120.01. Data analyses were partially supported by a National Science Foundation grant (No. G-11309) to the University of Pittsburgh Computing Center.

The proposal for this project was based on an award-winning research plan submitted by the Principal Investigator to the Television Research Plans Competition sponsored by the Television Bureau of Advertising (Gropper, 1963)*.

The authors are grateful to numerous people for their participation and cooperation in this project including: Dr. Evan Ingram of the Pittsburgh City Schools and Sister Rosalie of the Diocesan Schools in Pittsburgh for their help in enlisting the participation of pupils and teachers in this project; to the staff of WQED for their work in the production of televised lessons used in the project; to Charlotte Conley and Martha Scott for their aid in reproducing this report; and to Margaret Samways and Zita Glasgow for their preparation of programmed materials used in the study.

George L. Gropper
and
Gerard C. Kress, Jr.

December 1964

* Gropper, G. L. An experimental evaluation of procedures for "individualizing televised instruction. In L. Arons & M. A. May (Eds.) Television and Human Behavior - Tomorrow's research in mass communication. New York: Appleton-Century-Crofts, 1963.

ABSTRACT

Many students, particularly those with low ability, fail to meet the idealized standard for programmed lessons of less than 10 percent errors and better than 80-90 percent achievement. This does not occur because their ability is low. Other students at the same ability level working with the same programs demonstrate that they can meet these standards, one difference being that the achievers more often are those who work at a pace appropriate to their ability level. Many of those who fail do not. Moreover, not only is the pace adopted by students often inappropriate, it tends to be consistently so from program to program. Students exhibit characteristic work habits as reflected in the consistency both of the pace they adopt and of the frequency with which they commit errors. Neither consistent pattern is well predicted by the usual measures of ability.

These findings are based on data obtained from the administration of two self-paced science programs to two separate groups of eighth-grade students ($N = 252$ and 356). The principal ability measures obtained were Otis IQ and reading comprehension. The performance measures obtained for each program were: pretest score, time to complete a program, number of errors, and posttest score. Data were treated by correlational, regression, and variance analyses. The results discussed appear in sections describing: predictors of work rate, predictors of errors, and predictors of achievement.

The finding that sizeable numbers of students adopt work rates which are non-adaptive casts doubt on the wisdom of allowing all students to pace themselves and of relying on self-pacing to accommodate individual differences in ability. They suggest the need for greater control over the learning behavior of some students. The primary conclusion drawn from evidence reported in this study is that investigations are warranted to determine whether: (1) external control over a student's rate of work will improve performance whenever he demonstrates that, if left to his own devices, he works at an inappropriate rate; and (2) that the responses a student makes as a consequence of his own errors be guided so that achievement may be improved. It is anticipated that the implementation of these strategies can lead to high achievement for the sizeable numbers of students now failing to attain it primarily because they adopt inappropriate work rates.

TABLE OF CONTENTS

INTRODUCTION

2 METHOD

3 ANALYSIS OF DATA

RESULTS AND DISCUSSION

9 PREDICTORS OF WORK RATE

25 PREDICTORS OF ERRORS

39 PREDICTORS OF ACHIEVEMENT

CONCLUSION

55 ERRORS AND ACHIEVEMENT

55 SELF-PACING AND PERFORMANCE

57 ACCOMMODATING INDIVIDUAL
DIFFERENCES

58 STABILITY OF PERFORMANCE
MEASURES

59 IMPLICATIONS

INTRODUCTION

The behaviorist in discussing how subject-matter content is learned is apt to describe the goal of programmed instruction as the bringing of specific classes of student responses under the control of specific classes of stimuli. To accomplish this, he attempts to exercise control over the learning process itself in as systematic and precise fashion as he can. Implementation of the operant model in content preparation and the use of specially designed machines or textbooks in content presentation do indeed allow him to exercise far greater control over the learner's behavior than ever was the case in conventional instruction. But, he typically allows control over one feature of the learning process to be retained and exercised by the student himself. The learner is allowed to adopt the pace at which he learns. One of the most advertised and highly lauded virtues of programmed instruction is precisely the opportunity it provides the student to adopt a pace which is most congenial to him. High achievement across ability levels is thought to occur when programs are geared to the target population and this one measure of control remains in student hands.

What evidence is there that when left to his own devices the student is able or willing to adopt a pace which is optimal for him? What estimates are there of how much of the learning effectiveness attributable to programmed instruction derives from the opportunity it affords the student to pace himself?

Report #2 in this series (Kress & Gropper, 1964a) reviews some of the research comparing the relative effectiveness of self-paced and externally-paced programmed instruction. In it evidence from experiments completed during the present project is presented which bears directly on the wisdom of selecting a pace for the student rather than allowing him to do so himself. This report, in contrast, is concerned only with internal evidence of performance obtained from the administration of self-paced programs. It presents findings on the interrelationships between such individual differences variables as IQ and levels of entering knowledge and such performance variables as time to complete a program, errors,

and achievement. It also presents findings on the interrelationships among the performance variables themselves. By treating the performance variables of work rate (time to complete a program), errors, and achievement both as predictor and criterion variables, it is possible to shed light, not only on the merits of self pacing, but also on other key programming issues. These issues will be discussed in the result sections bearing the headings: Predictors of Work Rate, Predictors of Errors, and Predictors of Achievement.

Method

The results to be discussed in this report were obtained during the conduct of research on fixed-paced programmed instruction. Data became available for investigation of issues concerning self pacing when, prior to being exposed to fixed-paced programs on slides and on television, participating subjects (Ss) were given two self-paced programs. The programs were administered to them in order to provide all Ss with comparable knowledge of concepts necessary to be able to learn the material used in the fixed-paced experiments. So that the novelty of this type of instruction might be offset, participating Ss were also given a preliminary program on how to go through a program before they took the two self-paced programs proper. The data reported in this study were obtained from the administration of the two programs under self-paced conditions.

The two programs employed in this study were both in the general science area: a 108-frame program on "force" and a 96-frame program on "atomic structure." Both programs and their related achievement tests are presented, in their entirety, in Appendix A. Generally they may be characterized as linear, requiring constructed responses, building discriminations and generalizations through ample use of examples, and making heavy use of the "vanishing" technique whereby cue support is gradually reduced and responses become gradually longer and more complex.

The two programs were administered, on separate days, in the classrooms of the participating eighth-grade subjects. One group ($N = 267$) was observed in May (1963), the second ($N = 353$) in February of the following school year (1964). Each subject was given a booklet and

instructed to proceed at whatever pace he deemed appropriate for accurate responding. These sessions were preceded by practice with the preliminary programmed materials on how to go through a program and by pretests. Posttests were administered to each subject immediately upon completion of the programs. (For a more detailed description of these procedures see Reports #2 and #3 of this series.)

The results to follow will be based upon the two groups, group I (N = 267) and group II (N = 353), which after completing the self-paced programs participated in the experiments on programmed instruction presented at a fixed pace (described in Reports #2 and #3).¹ The measures recorded for each subject included: Otis-Group IQ scores, pretest scores, time taken to complete each of the two self-paced programs, errors committed during the programs, and posttest scores. In addition, a measure of reading comprehension was obtained for the subjects of group I.

The results to be reported are felt to have some generality based as they are on two separate programs with non-overlapping content, and having been administered to two large groups at separate times.

Analysis of Data

The variables studied included: IQ, Reading Comprehension, Pretest Scores, Work Rate, Errors, and Achievement Scores. As described above, the performance variables, work rate, errors, and posttest scores were treated in different analyses alternately as predictor and criterion variables.

Three main types of analyses were performed, including:

(a) correlational analysis. - Inter- and intra-program correlational analyses were performed for all variables under study.

(b) multiple regressions analysis. - Based on the correlational data, each of the three performance variables -- errors, work rate, and achievement for each of the two programs -- were treated as criterion variables in a multiple regression analysis. Beta (β) weights were

¹ Variations in the N for correlational data reported in various portions of this report are due to the dropout of some Ss in particular phases of the study; variations in N for variance analyses are due to differences in availability of Ss for matching purposes with different combinations of matching variables.

89
computed for predictor variables including the individual difference variables, IQ, pretest, and reading comprehension. Weights were similarly computed for the performance variables, work rate, errors, and achievement when they served as predictors. Since β weights tend to be relatively unstable, shifting in value with the addition of each new predictor measure to a battery or with their estimation based on different groups, they were computed from data obtained for each of the two groups on each of the two programs. This resulted in four such values which can be compared for consistency.

Also computed were the β_{1k}^2 values which indicate the percentage of unique variance in the criterion variable accounted for by each predictor variable in the battery. Since this measure also tends to be relatively unstable, four values of it were obtained to permit their consistency to be evaluated. The β_{1k}^2 values for all the variables in a battery cumulate to indicate the total variance in the criterion accounted for by the entire battery; this total is equal to R^2 , the Coefficient of Multiple Determination. Since this latter value is the most stable of the measures discussed so far, it will be a principal measure to be reported and discussed. Four values of R^2 , indicating the total percentage of variation in the criterion variable accounted for by a particular combination of predictor variables, will be shown for various combinations of predictor variables. Computational procedures used in these regression analyses are described by McNemar (1949).

(c) variance analysis. - While regression analysis provides information about the unique role of each predictor, with all others held constant, it does not reveal possible interactions among the several predictors. Therefore, to complement the regression analysis, variance analyses were performed for each criterion variable. Cases were selected from the total pool of Ss so that they were matched on the basis of all variables being studied save the predictor variable of interest. The procedure can be illustrated by the following example based on the matching of subjects for the variables IQ, Errors, and Pretest. A high-low cutting point based on median values was determined for IQ, Errors, and Pretest. This procedure led to eight distinct categories of subjects,

i.e., eight separate combinations of the three-way, high-low breakdowns leading to a 2x2x2 factorial design. Assignment of subjects to each cell of the design was accomplished by selecting sets of eight cases each who were as closely matched as possible on each non-differing variable and as different as possible on differing variables. The result was that groups which could be characterized as high and low on IQ were matched for and therefore did not differ on Pretest or Errors; high and low Error groups in turn were matched for and therefore did not differ on either IQ or Pretest; and high and low Pretest groups were matched for and therefore did not differ on IQ or Errors. In other words, since these variables are related, in order to assess the effect of each variable not confounded with the effect of the others, Ss were chosen in such a way as to maintain their independence and to prevent confounding. In order to assess the adequacy of the matching process, analyses of variance were performed with each independent variable, in its turn, treated as a dependent variable. Successful matching resulted in sizeable and significant separation between high and low levels of the independent variable (when treated as the dependent variable) and non-significant differences between levels of the other two independent variables. The results of the matching process for each analysis is presented in Appendix B. When the matching process involves as many as two, or three, or four variables, as it did in many of the analyses to be reported, the separation between levels for a given independent variable necessarily becomes smaller. For example, the difference in IQ between high and low levels of IQ becomes narrower. This results from the inability to find matches for the extreme cases on all the other variables. Due to the resulting narrower separation among levels, a certain amount of insensitivity as to effects due to the independent variable might be expected. When significant differences between levels nevertheless do occur, the magnitude of the differences obtained for the dependent variable under study probably represents an underestimate of the true impact of the independent variable in question.

In the prediction of all three criterion variables, Work Rate, Errors, and Achievement, results of all three types of analyses will be presented.

RESULTS AND DISCUSSION

In order to provide an overview of the general pattern of relationships among the individual difference and performance variables under investigation, a complete matrix of product-moment correlation coefficients was calculated from the data on both programs. Intra-program correlation coefficients based on data for groups I and II on the Atomics program are presented in Table 1, along with means, standard deviations, and Ns for each variable.² The analogous information relating to the Force program is presented in Table 2. Inspection of the tables indicates that the pattern of results for the two programs, and for the two groups on each of the programs, was quite similar. It appears that there were few gross differences between results for either the two groups or for the two programs, and differences which did occur were not so great as to change the general picture of consistency both between groups and between programs.

In all instances, Posttest score was directly related to IQ, Reading Comprehension and Pretest score. Both Errors and Work Rate, on the other hand, were inversely related to IQ, Reading Comprehension, and Pretest score. In summary, these data show that the higher IQ subjects tended to have higher pretest scores, spend less time to complete the programs, commit fewer errors in the process, and achieve higher posttest scores than did the lower IQ subjects. Each of the major performance variables: Work Rate, Errors, and Posttest were therefore IQ related, the magnitude of the relationship increasing in the order given.

Table 3 appearing on page 8 extends the picture of interrelationships by providing not only intra-program correlations but also inter-program correlations for both groups I and II. Worthy of note at this time are the relatively high correlations between: (a) Work Rate on one program and Work Rate on the other, $r = .759$ for group I and $r = .833$

² Means for Pre- and Posttest scores are in percentages; Work Rate results are the mean number of minutes taken to complete programs; and the Error data are raw score means (analyses performed on log Error scores).

Table 1
Intercorrelations Among Individual Differences Variables
and Performance Variables for the ATOMICS Program

	<u>Reading Comp.</u>	<u>Pretest</u>	<u>Work Rate</u>	<u>Errors</u>	<u>Posttest</u>	<u>Mean</u>	<u>S.D.</u>	<u>N</u>
	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II
IQ	.68 *	.52 .66	-.43 -.32	-.60 -.62	.71 .69	108.5 109.3	12.4 11.8	267 353
Reading Comp.		.50 *	-.33 *	-.48 *	.65 *	12.5 *	4.1 *	258 *
Pretest			-.41 -.25	-.47 -.52	.51 .65	27.4 28.8	21.0 19.1	263 334
Work Rate				.25 .16	-.32 -.12	46.1 47.6	8.0 9.2	258 335
Errors					-.67 -.70	16.8 23.7	20.7 25.8	256 335
Posttest						80.5 76.1	22.0 24.9	258 335

Table 2
Intercorrelations among Individual Differences Variables
and Performance Variables for the FORCE Program

	<u>Reading Comp.</u>	<u>Pretest</u>	<u>Work Rate</u>	<u>Errors</u>	<u>Posttest</u>	<u>Mean</u>	<u>S.D.</u>	<u>N</u>
	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II	Group I Group II
IQ	.68 *	.47 .45	-.44 -.33	-.55 -.60	.69 .68	108.5 109.3	12.4 11.8	267 353
Reading Comp.		.41 *	-.37 *	-.49 *	.61 *	12.5 *	4.1 *	258 *
Pretest			-.31 -.20	-.38 -.34	.48 .43	29.4 25.9	14.0 12.0	263 339
Work Rate				.18 .04	-.34 -.09	44.5 49.8	6.7 9.7	253 338
Errors					-.65 -.65	16.8 27.1	20.1 24.5	252 335
Posttest						76.2 73.1	19.3 19.8	252 337

*Not obtained for Group II.

Table 3

Inter-Program Correlations Among
Individual Differences Variables and Performance Variables

	<u>Pretest Force</u>		<u>Pretest Atomics</u>		<u>Work Rate Force</u>		<u>Work Rate Atomics</u>		<u>Errors Force</u>		<u>Errors Atomics</u>		<u>Posttest Force</u>		<u>Posttest Atomics</u>	
	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
IQ	.47	.45	.52	.66	-.44	-.33	-.43	-.32	-.55	-.60	-.60	-.62	.69	.68	.70	.69
Pretest Force			.52	.50	-.31	-.20	-.31	-.20	-.38	-.34	-.44	-.34	.48	.42	.39	.42
Pretest Atomics					-.26	-.19	-.41	-.25	-.42	-.50	-.46	-.52	.48	.56	.51	.64
Work Rate Force							.76	.83	.18	.04	.22	.16	-.34	-.09	-.28	-.09
Work Rate Atomics									.23	.07	.25	.16	-.39	-.09	-.32	-.12
Errors Force											.73	.83	-.64	-.65	-.70	-.65
Errors Atomics													-.59	-.65	-.67	-.70
Posttest Force															.74	.77
Posttest Atomics																

for group II; (b) Errors on one program and Errors on the other, $r = .733$ for group I and $r = .834$ for group II; and (c) Posttest score on one program and Posttest score on the other, $r = .741$ for group I and $r = .773$ for group II. The magnitude of the self-correlations for these three variables, indicating their moderately high reliability, suggests that they are perhaps stable measures and, in some sense, may be thought of and used as individual difference variables predictive of other performance variables. This will be treated in more detail in the analyses to follow which attempt to portray both the separate and the interactive roles of the several variables under investigation.

Predictors of Work Rate

The length of time which subjects spend in completing a program is typically regarded as one of the key variables by which individual differences in ability are absorbed. As such, it is to be expected that IQ, prior knowledge of the subject matter, and, perhaps, reading ability, would account for inter-individual differences in Work Rate. And if, in fact, a self-selected pace does effectively allow for and does accommodate individual differences in ability, it might also be expected that successful or unsuccessful progress through a program might provide a stimulus to alterations in pace. Thus, experienced difficulty (as reflected in error rates) might also be expected to account for variations in Work Rate.

Table 4 appearing on page 10 presents the coefficient of determination (R^2) for various combinations of variables predicting Work Rate. Generally it can be seen by inspection that the combination of IQ and Pretest score (line 1) account for only a small portion of the variance associated with Work Rate. The average of the four R^2 values presented (for two programs and two groups) is 16 percent. The addition of Reading Comprehension or of Error score to the battery contributes relatively little extra to this predictive power. On the other hand, the addition of Work Rate on another program (line 4) adds considerably. Taken together, IQ, Pretest, and Work Rate (on one program) account for approximately 65 percent of the variance associated with Work Rate on another program. These results show appreciable similarity across programs and across groups.

Table 4
Coefficients of Multiple Determination (R^2)
indicating the percentage of variance in Work Rate
associated with various combinations of predictor variables

<u>Predictor Variables</u>	<u>Force Program</u>		<u>Atomics Program</u>	
	<u>Group I</u>	<u>Group II</u>	<u>Group I</u>	<u>Group II</u>
Pretest + IQ	.173	.114	.235	.107
Reading Comp. + Pretest + IQ	.214	*	.235	*
Errors + Pretest + IQ	.218	.157	.241	.108
Work Rate + Pretest + IQ on other program	.594	.699	.624	.702
Reading Comp. + Work Rate + Pretest + IQ on other program	.595	*	.627	*
Errors + Work Rate + Pretest + IQ on other program	.597	.705	.624	.705

*Not obtained for Group II.

The following sections provide more detailed results based on both regression and variance analyses indicating the extent to which each of the separate variables does account for Work Rate.

IQ and IQ-Related Variables as Predictors of Work Rate

In allowing the individual student to pace himself, it is generally assumed that above average students can and will work quickly and that below average students can and will work more slowly taking as much time as needed. It is this self-selected pace which is thought to allow individual differences in ability to be accommodated. Evidence collected to date does consistently indicate a negative relationship between ability measures and time to complete a program (Work Rate), but estimates of the magnitude of this relationship vary considerably. The highest estimates were obtained by Cook (1963) who found an orderly negative relationship (magnitude unspecified) between IQ and time for 13 Ss who took an 800-frame chemistry program, and by Carroll (1963) who reported

a high correlation ($r = -.77$) between time on a Mandarin Chinese Program and the Carroll-Sapon Modern Language Aptitude Test. A lesser estimate was obtained by Silberman, Melaragno, Coulsen, and Estavan (1961), who found a rho of $-.52$ between time to complete a multiple-choice response program and scores on the Henmon-Nelson Test of Mental Ability. By far the smallest estimate was reported by Alter (1962) who found an IQ-Time correlation of only $-.24$ for students who took a mathematics program. Alter concluded that "intelligence is not a particularly useful predictor of time taken to complete the program." The wide range of values reported in these studies may, in large part, be attributable to differences in the types of program used or in the types of ability measures used. Thus, while ability and time are clearly inversely related, the magnitude of the relationship has as yet not been clearly established. This being the case, it is somewhat surprising to note how much of the accommodation of individual differences is attributed to the self-pacing capability of programmed instruction.

As can be seen from the findings presented in Tables 1, 2, and 3, correlations obtained in this study between IQ (Otis) and Work Rate range from $r = -.32$ to $r = -.43$, the average being $r = -.38$. These correlations, based on two separate programs which were administered to two separate, large groups, are statistically significant and appear to be relatively reliable measures. They indicate a moderate, inverse relationship between IQ and Work Rate. Scattergrams for two of the four obtained correlations (those for group II, the larger of the two groups) are presented in Fig. 1 and 2 appearing on page 12. With median lines drawn in for both IQ and Work Rate to form quadrants, it can be readily seen that high IQ Ss tend to be fast, and low IQ Ss tend to be slow. But substantial numbers in both IQ categories deviate from this pattern. While Ss exhibit considerable variability in Work Rate, ranging from slightly less than 30 to slightly more than 80 minutes on both programs, this variability parallels the variability in IQ to only a moderate degree.

Based on the highest of the four obtained correlations between IQ and Work Rate, it can be seen that IQ as a sole predictor of Work Rate accounts for no more than 18 percent of the variance. As can be seen from Table 4, which summarizes coefficients of multiple determination,

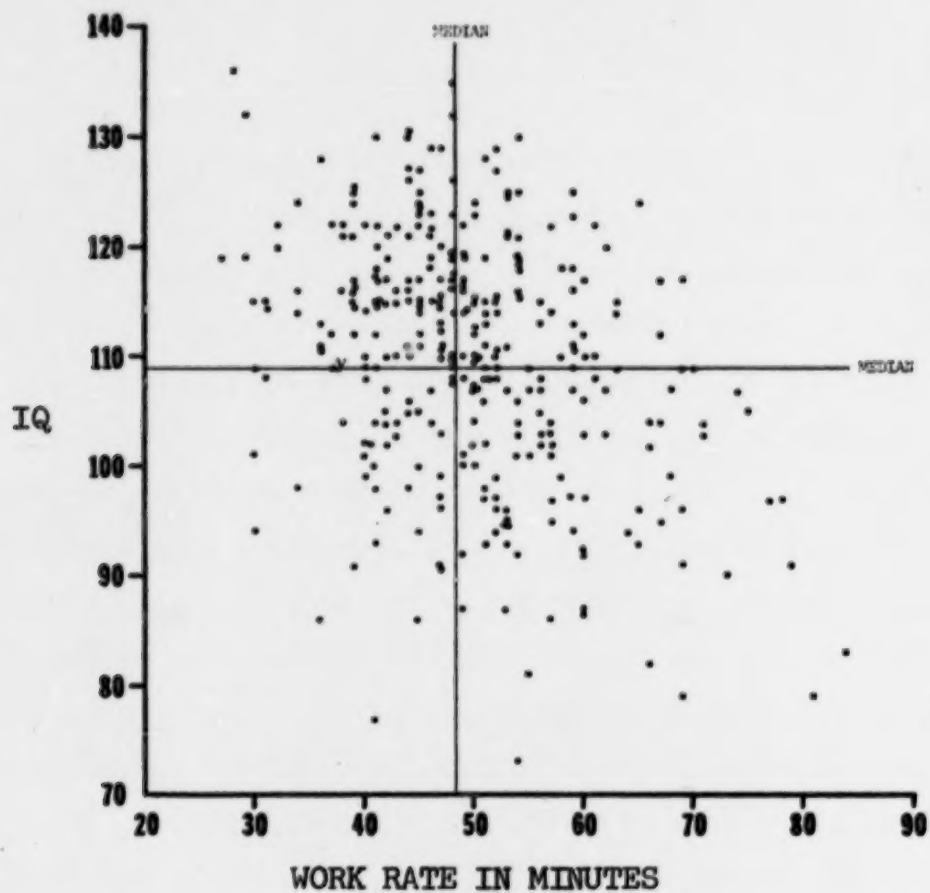


FIGURE 1

Bivariate Distribution of IQ and Work Rate on the Force Program ($r = -.33$)

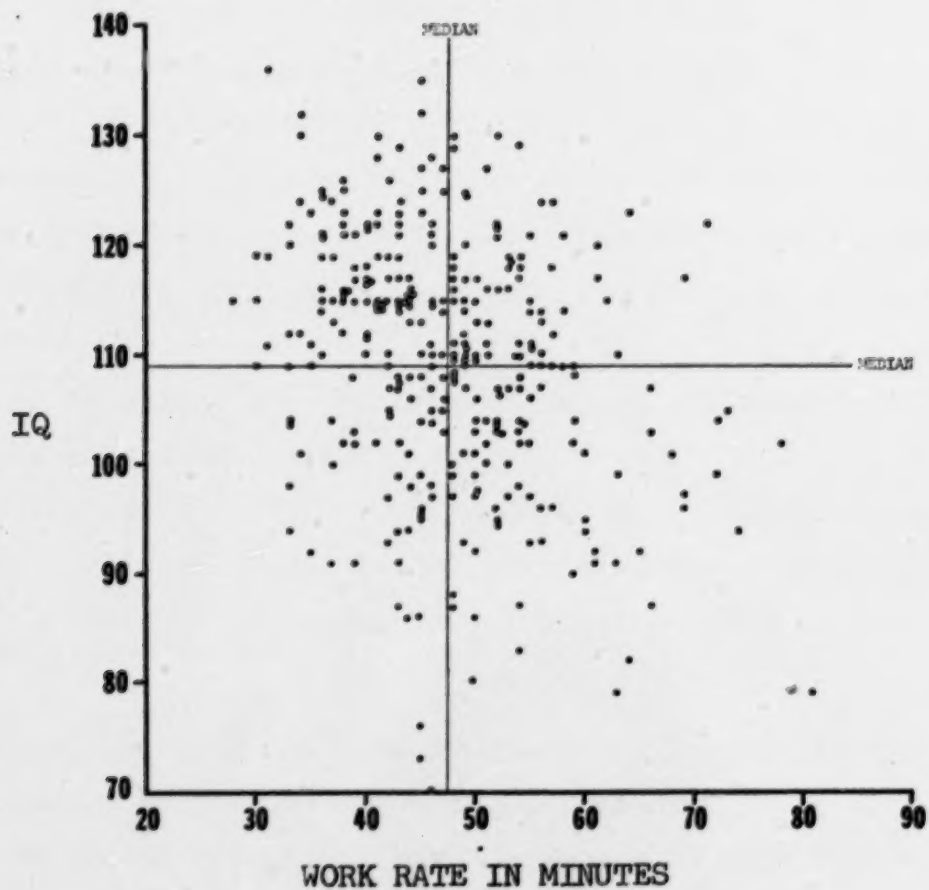


FIGURE 2

Bivariate Distribution of IQ and Work Rate on the Atomics Program ($r = -.32$)

IQ, when taken in combination with other IQ related measures, such as Reading Comprehension and Pretest scores, accounts for only a slightly higher portion of the variance associated with Work Rate.

Regression analyses have permitted an estimate of the separate or combined effect of various IQ related measures on Work Rate. They have not permitted an analysis of the interactive effects between these variables. To gather evidence on this possibility, several variance analyses were performed. One of these treated IQ, Errors, and Pretest scores as independent variables, each divided into two levels, high and low. High and low Ss for each independent variable were matched on the basis of the other two variables, thus insuring that the effect of the three variables would not be confounded. (Tables 1 to 8 in Appendix B provide data indicating that subjects were successfully matched.)

Tables 5 and 6 on page 14 summarize results of the variance analysis for the Atomics program. Table 5 presents the means and standard deviations for the high-low levels on each independent variable thus indicating their degree of separation. The mean IQ for the high IQ group is 116, that for the low IQ group 105. The mean number of errors (out of a possible 162) was 34 for the high Error group to 13 for the low Error group. The mean percentage on the Pretest for the high Pretest group was 33, that for the low Pretest group 15. Table 5 also provides the means for the dependent variable Work Rate for each of these levels. Inspection of these latter means and the summary of the analysis of variance in Table 6 reveals that there are significant differences in Work Rate between high and low IQ groups. On both the Atomics program and the Force program, the results for the Force program appearing in Tables 7 and 8 on page 15, the low IQ Ss took longer to complete their work. The low IQ Ss took 50.42 minutes to the high IQ's 45.48 minutes on the Atomics program, this difference being significant ($P < .01$). Low IQ Ss took 52.56 minutes to the high IQ's 45.58 minutes on the Force program with this difference also significant ($P < .001$).

These results complement the correlational analysis showing a negative relationship between IQ and Work Rate. They reveal, however, no interaction between IQ and either of the other two variables, Pretest or Errors.

Table 5
Summary Results for Work Rate on the ATOMICS Program
by Levels of Each Independent Variable
(N = 104)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Work Rate		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	116.37	3.11	45.48	8.08	**
	Low IQ	105.23	4.33	50.42	8.13	

B.	High Errors	29.79	9.00	47.71	9.03	
	Low Errors	10.08	4.72	48.19	7.88	

C.	High Pretest	33.77	6.38	47.37	7.97	
	Low Pretest	15.42	4.18	48.54	8.92	

Table 6
Summary of the Analysis of Variance
for Work Rate on the ATOMICS Program
(N = 104)

<u>Source</u>	<u>D.F.</u>	<u>Mean Squares</u>	<u>F</u>
A (IQ)	1	635.09	9.69**
B (Errors)	1	6.01	-
C (Pretest)	1	35.78	-
AB	1	35.78	-
AC	1	19.47	-
BC	1	231.01	3.53
ABC	1	83.16	1.27
Within Replicates	96	65.52	

**significant beyond the .01 level

Table 7
Summary Results for Work Rate on the FORCE Program
by Levels of Each Independent Variable
(N = 104)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Work Rate		
		<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>	<u>P</u>
A.	High IQ	116.02	2.55	45.58	8.47	***
	Low IQ	104.88	4.22	52.56	8.36	

B.	High Errors	34.00	8.10	47.88	9.62	
	Low Errors	13.37	4.64	50.25	8.42	

C.	High Pretest	32.92	5.29	46.48	8.51	**
	Low Pretest	19.00	4.26	51.65	8.97	

Table 8
Summary of the Analysis of Variance
for Work Rate on the FORCE Program
(N = 104)

Source	D.F.	Mean Squares	F
A (IQ)	1	1267.01	19.83***
B (Errors)	1	145.47	2.28
C (Pretest)	1	695.78	10.89**
AB	1	122.78	1.92
AC	1	57.01	-
BC	1	11.78	-
ABC	1	54.09	-
Within Replicates	96	63.88	

**significant beyond the .01 level
***significant beyond the .001 level

Pretest, which is IQ related, can be seen to have proved significant on only one of the two variance analyses. In conjunction with the correlational and regression analyses this indicates that, when accompanied by IQ as a predictor, Pretest scores contribute relatively little unique variance in predicting Work Rate. This is a somewhat surprising result. It might be expected that the more a student knows about the subject matter the more quickly he should be able to proceed through the program regardless of ability.

It can be said that IQ and other IQ related measures (Pretest and Reading Comprehension) are moderately predictive of Work Rate. The highest of the four multiple correlations they yield is $R = .48$, and thus they account for 23 percent of the variance associated with Work Rate. While it is generally assumed that able students can efficiently progress through programs, requiring less time than their less able fellow students, a large minority do not take less time. Further evidence for this was obtained when Ss in group II ($N = 312$) were categorized as falling in high, medium, or low IQ sub-groups and as falling in fast, medium or slow Work Rate sub-groups, thus creating more extreme groupings than was the case in previously described analyses which used the median as a high-low cutting point. On the Atomics program, as many as 23 percent of the high IQ Ss (that is, 23 percent of the top third of the ability distribution) were characterized as slow workers (the bottom third of the Work Rate distribution). On the Force program, 26 percent of the high IQ Ss were characterized as slow workers. When Ss were further characterized for consistency of Work Rate, that is, fast, medium, or slow on both programs, it was found that 19 percent of the total group of Ss in the upper third of the ability distribution (high IQ) were consistently slow.

As to the less able students, they do not uniformly take the time they are assumed to require. Among low IQ Ss, 16 percent on the Atomics program and 22 percent on the Force program were found to be fast workers. It was also found that 8 percent of the total group of Ss in the lower third of the ability distribution (low IQ) were consistently fast on both programs.

In summary, it can be seen from the various analyses that ability and ability related measures do account for some of the differences which

Ss exhibit in Work Rate. While it is generally true that able students tend to work at a fast pace and less able students to work at a slow pace, this is not uniformly so. Sizeable numbers of students deviate from this pattern. Therefore, it is apparent that, if Work Rate is to be analyzed fully, variables other than ability variables must be identified which can account for, by far, the major portion of the variance associated with it.

Errors as Predictors of Work Rate

A student's progress through a program might be expected to influence his pace. High error frequency might be expected to slow him up, to cause him to work more slowly in succeeding frames or perhaps to reread material. The data available from this study do not permit an analysis of variations in Work Rate which may have occurred during the program. It is still possible, nevertheless, to relate overall Error frequency with overall Work Rate and to contrast the Work Rate of those who committed many Errors with the Work Rate of those who committed few Errors.

As shown in Tables 1 and 2, correlations between Errors and Work Rate, based on two programs and two groups, ranged from $r = .04$ to $r = .25$, with an average of $r = .13$. Thus, even for the highest value, Errors accounted for no more than 6 percent of the variance in Work Rate. This minimal role was further confirmed in the multiple regression analysis, summarized in Table 4. In view of the high correlation between Errors and IQ ($r = -.601$), it is significant that, as shown in line 3, Errors added little to the predictive power of IQ and Pretest. Variance analyses, summarized in Tables 5 to 8, reveal that the high Error group which made approximately three times as many errors as the low Error group was not significantly different from it on the dependent variable, Work Rate. The error rate for the high Error group was approximately 18 percent, for the low Error group approximately 6 percent. If error rate were to influence work rate, the error rates observed here were of sufficient magnitude to do so. It appears on the basis of these findings that Errors do not materially affect Work Rate. Assuming that Ss read confirmation frames and correctly discriminate between occasions when they have made an error and when they have not, experienced difficulty, as reflected in error data, apparently leads to little alteration in self-selected work rate.

Work Rate on One Program as a Predictor of Work Rate on Another

In well tried-out programs, where ideally error rates are systematically kept low, Ss nevertheless do experience varying degrees of difficulty, presumably as a function of their ability and/or prior knowledge. Variations in self-pacing might be expected to accompany variations in ability (and presumably experienced difficulty). In one further set of variance analyses to assess this assumption, the results of which are summarized in Tables 9 to 12, high and low IQ Ss who were matched for Work Rate on one program no longer differed significantly on Work Rate on a second program. Indeed, when groups of Ss were matched on all four variables, IQ, Pretest, Work Rate (on another program), and Errors, the only consistent, significant predictor of Work Rate was Work Rate on another program. (Data indicating the success of the matching procedures are presented in Tables 9 through 18 in Appendix B.) This result might be expected in view of the high correlations found between Work Rate on one program and Work Rate on another. As shown in Table 3, the correlations for groups I and II were $r = .76$ and $r = .83$ respectively. With IQ partialled out these correlations become $r = .70$ and $r = .81$. In view of this latter finding, it is not surprising to find, as indicated in Table 4 (line 4), the marked increase in the percentage of variance in Work Rate which can be accounted for by the addition of Work Rate (on another program) to the battery of predictors. The average R^2 (percent variance accounted for) jumps from 18 percent to 65 percent.

Work Rate, because of its high inter-program correlations, appears to be a highly stable characteristic of Ss. Further evidence of this stability can be seen in the consistent appearance of Ss in the fast, medium, and slow Work Rate categories for both programs. When Ss in group I ($N = 312$) were categorized as fast, medium, or slow on one program, 69 percent of them were similarly categorized on the second program. There appear to be IQ differences, however, in such consistency. High IQ Ss led in consistency, 77 percent consistent, followed by medium IQ Ss, 71 percent consistent, with low IQ Ss trailing at 59 percent consistent.

The variance analyses shown in Tables 9 to 12, also indicate that Ss appearing in the high/low breakdowns for Work Rate on one program were

Table 9
Summary Results for Work Rate on the ATOMICS Program
by Levels of Each Independent Variable
(N = 96)

	Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Work Rate		
	Mean	S.D.	Mean	S.D.	P
A. High IQ	115.48	3.40	47.21	8.53	
A. Low IQ	103.52	4.46	47.06	8.23	
B. High Pretest	34.04	5.75	45.73	7.21	
B. Low Pretest	15.71	5.41	48.54	9.19	*
C. Fast Work Rate (Force)	41.79	5.20	41.69	5.99	
C. Slow Work Rate (Force)	55.13	4.47	52.58	6.64	***
D. High Errors	31.25	12.34	47.35	8.98	
D. Low Errors	9.71	3.52	46.92	7.73	

Table 10
Summary of the Analysis of Variance
for Work Rate on the ATOMICS Program
(N = 96)

Source	D.F.	Mean Squares	F
A (IQ)	1	.51	-
B (Pretest)	1	189.84	4.69*
C (Work Rate [Force])	1	2849.26	70.38***
D (Errors)	1	4.59	-
AB	1	4.59	-
AC	1	.09	-
AD	1	.84	-
BC	1	49.59	1.22
BD	1	.26	-
CD	1	102.09	-
ABC	1	4.59	-
ABD	1	31.51	-
ACD	1	119.26	2.95
BCD	1	5.51	-
ABCD	1	.84	-
Within Replicates	80	40.55	

*significant beyond the .05 level
***significant beyond the .001 level

Table 11
Summary Results for Work Rate on the FORCE Program
by Levels of Each Independent Variable
(N = 80)

	Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Work Rate		
	Mean	S.D.	Mean	S.D.	P
A. High IQ	113.35	2.77	49.03	7.96	
Low IQ	103.53	4.77	50.83	8.67	

B. High Pretest	31.50	5.67	49.63	8.07	
Low Pretest	16.60	4.11	50.23	8.65	

C. Fast Work Rate (Atomics)	42.03	4.45	44.03	5.65	
Slow Work Rate (Atomics)	53.95	3.32	55.82	6.06	***

D. High Errors	33.85	8.28	49.93	8.85	
Low Errors	12.30	4.74	49.93	7.86	

Table 12
Summary of the Analysis of Variance
for Work Rate on the FORCE Program
(N = 80)

Source	D.F.	Mean Squares	F
A (IQ)	1	64.80	1.74
B (Pretest)	1	7.20	-
C (Work Rate [Atomics])	1	2784.80	74.91***
D (Errors)	1	.00	-
AB	1	8.45	-
AC	1	4.05	-
AD	1	22.05	-
BC	1	4.05	-
BD	1	.05	-
CD	1	68.45	1.84
ABC	1	5.00	-
ABD	1	7.20	-
ACD	1	1.80	-
BCD	1	39.20	1.05
ABCD	1	68.44	1.84
Within Replicates	64	37.19	

***significant beyond the .001 level

significantly different from one another on the second program. With Slows and Fastes determined by performance on one program, the difference between them on the second program is approximately 11 minutes ($P < .001$). Those who were slow on the first program were slow on the second program. And, indeed, when Ss are matched for Work Rate on one program, all other high/low breakdowns including high/low levels of IQ, Pretest, and Errors (save Pretest on one program), show no significant differences in Work Rate on the second program.

Summary

Tables 13 and 14 appearing on page 22, providing summary results of regression analyses for the most complete combination of predictors, reflect the high predictive power of Work Rate on one program in predicting Work Rate on another. The relatively lower predictive power for IQ, Pretest, and Reading Comprehension can be seen from an inspection of their beta weights (β) and of the $\beta.r$ values, indicating the percentage of the variance accounted for by each predictor in the battery.

While these analyses testify as to the high predictive power of Work Rate, a review of Tables 5 to 8 will reveal that IQ, when Ss are not matched for Work Rate, does predict Work Rate. Indeed, when Ss are categorized into high, medium or low IQ groups and into fast, medium, or slow Work Rate groups, the following results testify as to the relationship of IQ and Work Rate. Approximately 50 percent of the high IQ Ss completed programs at the fast Work Rate. Approximately 55 percent of the low IQ Ss completed programs at the slow Work Rate. Thus, IQ and Work Rate are moderately related and this relationship is in keeping with the assumptions underlying the unrestricted freedom given Ss in selecting a pace which will accommodate their needs. But, it needs emphasizing, approximately 21 percent of the high IQ Ss were characterized as slow workers and approximately 20 percent of the low IQ Ss were characterized as fast workers. Many high IQ Ss thus may not be working as efficiently as may be desired. And, as it might be expected, many low IQ Ss may not be working as effectively as may be desired. Preliminary data bearing on the former question can be found in subsequent reports on fixed pacing in

Table 13

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Work Rate on Atomics Program
 Predictor Variables: IQ, Reading Comprehension, Pretest, and Work Rate
 Group I (N = 267) on other program

Intercorrelations						Mean	S.D.	N
	Work Rate X_1	IQ X_2	Read. Comp. X_3	Pre- test X_4	W.R. Force X_5			
Work Rate Atomics X_1		-.43	-.33	-.41	.76	46.11	8.01	258
IQ X_2			.68	.52	-.44	108.49	12.37	267
Reading Comp. X_3				.50	-.37	12.54	4.12	258
Pretest Atomics X_4					-.26	27.41	21.02	263
Work Rate Force X_5						44.47	6.74	253

Regression Analysis				
		β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$
IQ X_2		-.055	-.433	.024
Reading Comp. X_3		.080	-.334	-.027
Pretest Atomics X_4		-.237	-.411	.097
Work Rate Force X_5		.702	.759	.533

R^2 1.2345 = .627
 R 1.2345 = .792
 σ 1.2345 = 3.651

Table 14

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Work Rate on Force Program
 Predictor Variables: IQ, Reading Comprehension, Pretest, and Work Rate
 Group I (N = 267) on other program

Intercorrelations						Mean	S.D.	N
	Work Rate X_1	IQ X_2	Read. Comp. X_3	Pre- test X_4	W.R. Atomics X_5			
Work Rate Force X_1		-.44	-.37	-.31	.76	44.47	6.74	253
IQ X_2			.68	.52	-.43	108.49	12.37	267
Reading Comp. X_3				.50	-.33	12.54	4.12	258
Pretest Force X_4					-.31	29.38	14.04	263
Work Rate Atomics X_5						46.11	8.01	258

Regression Analysis				
		β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$
IQ X_2		-.087	-.442	.038
Reading Comp. X_3		-.072	-.369	.027
Pretest Force X_4		-.010	-.307	.003
Work Rate Atomics X_5		.694	.759	.527

R^2 1.2345 = .595
 R 1.2345 = .771
 σ 1.2345 = 4.293

this series. The answer to the latter question will depend on how Work Rate is found to affect Errors and Posttest scores (to be discussed below).

In general, it appears that Work Rate: is a relatively stable characteristic of individuals, is only moderately a function of ability, and is uninfluenced by how many errors Ss make while going through a program. In view of these findings, it is somewhat open to question whether self-pacing in programmed instruction bears the major portion of the burden in accommodating individual differences in ability. It very well may be that, when Ss are allowed to pace themselves, many of them actually do work at a pace appropriate to their ability. But many do not and it may be that accommodation is largely accomplished by the level at which a program is geared both in its initial preparation and in its tryout and revision. It is entirely conceivable that what is generally referred to as "step size" may absorb individual differences to a far greater degree than does the opportunity to pace oneself. Partitioning out the contribution of each to the accommodation of ability difference merits investigation.

It is interesting to speculate as to other variables, not available for study here, which may more fully account for the apparent stability of Work Rate on programmed materials. Tate (1948), in studying the stability of speed of response to test items varying in the function being measured, in its difficulty, and in the accuracy with which they were responded to, found that "Ss who were fast in response to items at one level of difficulty tended to be fast at other levels" and that Ss "who were fast in one function tended to be fast in another" suggesting the existence of a general speed ability. It is reasonable to suppose that stability in Work Rate on programmed materials is in large part due to S's characteristic reading speed and general work habits. Experience in watching different Ss go through a program will readily confirm considerable variation in how Ss deal with frames, from those who pore over each word, perhaps pointing to each or even verbalizing with lips moving, to those who put pencil to paper very quickly after being exposed to a new frame. Support for the position that typical work habits may also account for the stability of work rate will shortly be presented in a discussion of the high reliability of Errors (from program to program).

Research on reading speed has already shown that it is stable over time and across reading matter. In a recent study by Kershner (1964), for example, a correlation of .72 was found between reading speed on two groups of material which varied in difficulty. On material equated for difficulty, the correlation was $r = .81$. These correlations suggest the high stability of reading speed. The fact that ability contributes only moderately to Work Rate and prior knowledge almost negligibly, suggests that personal style and reading speed may indeed be the key factors.

If it should prove to be the case that Work Rate reflects reading speed and personal work style more than, or at least as much as, it does ability, serious questions are raised as to the wisdom of allowing Ss on their own to do the selecting of a pace which can be relied on to be appropriate to their ability level. In addition to doing less accommodation of individual differences than it is generally credited with, allowing Ss to pace themselves may result in unexpected and potentially deleterious effects on performance. The analysis of the effect of Work Rate on Errors and Achievement (to follow in the next section) will shed light on this possibility.

Predictors of Errors

Error rate is of interest to the programmer both as an independent and as a dependent measure. As a dependent measure it is assumed to reflect program difficulty and is typically employed during the tryout of programs as a guide for their revision. As an independent measure it is assumed to influence achievement. For this reason many linear programmers, in keeping with the views expressed by Skinner (1954) and by Holland (1960), hold that error rates should be kept low.

The relationship between errors and achievement, as revealed by the data available in this study will be explored in detail in the section on "Predictors of Achievement." Here, we are concerned with the variables which predict Errors. It might be hypothesized that, as in the case of work rate, ability and prior knowledge of a subject matter will be highly predictive of errors. Further, on tried out programs the pace at which Ss work through a program will, if Ss are capable of and actually do appropriately select their own pace, not significantly influence the number of errors committed. However, should a failure in self-selection of a pace occur, then those who work fast might be expected to commit more errors than those who work at a more deliberate pace.

Table 15 presents the coefficients of multiple determination (R^2) for various combinations of variables predicting the number of Errors committed.

Table 15
Coefficients of Multiple Determination (R^2)
indicating the percentage of variance in Errors
associated with various combinations of predictor variables

<u>Predictor Variables</u>	<u>Force Program</u>		<u>Atomics Program</u>	
	<u>Group I</u>	<u>Group II</u>	<u>Group I</u>	<u>Group II</u>
Pretest + IQ	.324	.371	.382	.408
Work Rate + Pretest + IQ	.338	.401	.382	.426
Errors + Work Rate + Pretest + IQ on other program	.578	.758	.601	.722

Generally, it can be seen by inspection that Pretest and IQ on the average account for approximately 38 percent of the variance associated with Errors. This exceeds their power to predict Work Rate and accounts reasonably well for the occurrence of errors. Nevertheless, as was the case with addition of "Work Rate on one program" to the battery predicting Work Rate on another, the addition of "Errors on one program" to the battery markedly increases its power to predict Errors on a second program. The percentage of the variance in Errors accounted for jumps from 38 percent to an average of 65 percent.

The following sections provide more detailed results based on both regression and variance analyses indicating the extent to which each of the separate variables does predict Errors.

IQ and IQ-Related Variables as Predictors of Errors

It is generally assumed that, by allowing students to pace themselves and by pretesting and revising materials with a sample of students from the target population, differences in ability can be successfully bridged with one program. Even with well tried out programs errors do occur and efforts are made by most programmers to keep them at no higher than the 10 percent level. The mean number of Errors on the programs used in this study was approximately 10 percent for the Atomics program and 8 percent for the Force program. The intent of these analyses is, of course, to account for the variability in the distribution of Errors around these values and to account generally for successful progress through a well tried out program by some students but not by others.

Errors have been found to be related to IQ and Pretest. Smith and Moore (1961) reported significant correlations between IQ and errors. Shay (1961) reported a correlation of $-.51$ for pretest scores and errors. Inasmuch as abler students still commit fewer errors than their less able fellows, much as they do with other more conventional types of instruction, it would appear that programmed instruction is not necessarily the leveler it is expected to be.

The correlations between IQ and Errors reported in Tables 1 and 2 ranged from $r = -.55$ to $r = -.62$ with the average of the four reported r 's in these tables being $r = -.59$. Thus, IQ alone accounts for approximately 35 percent of the variance in Errors. Pretest correlations with

Errors range from $r = -.34$ to $r = -.52$, with the average of the four reported values being $r = -.43$. Thus, Pretest alone accounts for approximately 18 percent of the variance. Because of the high correlation between IQ and Pretest, IQ and Pretest together account for only 38 percent of the variance or slightly more than IQ does alone.

These findings are supported by variance analyses, which treat IQ, Pretest, and Work Rate as independent variables and Errors as the dependent variable. Once again, Ss in high and low breakdowns for each variable, were matched on the basis of the other two variables making for independence of effects. (Results of the matching process are summarized in Tables 19 to 26 in Appendix B.) Table 16 appearing on page 28 presents the means for the high and low levels of each independent variable which indicate their degree of separation. It also presents the means on the dependent variable, Errors on the Atomics program for each of these levels. Table 18 appearing on page 29 presents the same information for the Force program. As can be seen from both these tables, low IQ Ss committed half again as many errors as the high IQ Ss on the Atomics program and twice as many on the Force program. The F ratios in Tables 17 and 19 indicate that these differences in mean number of Errors between high and low IQ Ss were significant ($P < .001$).

Means for high and low Pretest Ss revealed similar results, with low Pretest Ss scoring more errors. This finding was upheld on both programs but was significant only for the Atomics program ($P < .001$). Coupled with the evidence of a relatively low amount of unique variance contributed by Pretest as a predictor of Errors, this is a somewhat surprising result. It might be expected that prior knowledge of the subject matter would materially influence the number of errors a student commits in working through a program or the rate at which he works through a program. This did not uniformly prove to be the case, however.

It can be said on the basis of evidence presented here and elsewhere by others, that, even in programmed instruction where systematic attempts are made to keep error rates low through suitable manipulation of step-size and other program characteristics, differences between high and low ability Ss still exhibit themselves. IQ and Pretest scores predict errors moderately well. Together they accounted for approximately 38 percent of the variance in Errors. Thus, while IQ and Pretest appear to be

Table 16
Summary Results for Errors on the ATOMICS Program
by Levels of Each Independent Variable
(N = 144)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Errors		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	116.68	4.46	16.06	12.84	***
	Low IQ	105.50	4.31	25.01	19.10	

B.	High Pretest	36.17	6.09	15.60	13.34	***
	Low Pretest	17.78	5.31	25.47	18.51	

C.	Fast Work Rate	41.22	4.54	23.33	19.12	*
	Slow Work Rate	53.28	4.83	17.74	13.75	

Table 17
Summary of the Analysis of Variance
for Log Errors on the ATOMICS Program
(N = 144)

Source	D.F.	Mean Squares	F
A (IQ)	1	1.50	12.60***
B (Pretest)	1	1.94	16.32***
C (Work Rate)	1	.54	4.52*
AB	1	.35	2.92
AC	1	.13	1.08
BC	1	.07	-
ABC	1	.14	1.18
Within Replicates	136	.12	

*significant beyond the .05 level
**significant beyond the .01 level
***significant beyond the .001 level

Table 18
Summary Results for Errors on the FORCE Program
by Levels of Each Independent Variable
(N = 136)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Errors		
		<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>	<u>P</u>
A.	High IQ	118.10	3.95	16.06	11.84	***
	Low IQ	103.19	5.07	32.22	21.58	

B.	High Pretest	34.47	6.52	22.04	17.27	
	Low Pretest	16.88	4.98	26.24	20.77	

C.	Fast Work Rate	41.66	4.88	28.49	22.99	*
	Slow Work Rate	54.81	4.26	19.79	13.10	

Table 19
Summary of the Analysis of Variance
for Log Errors on the FORCE Program
(N = 136)

Source	D.F.	Mean Squares	F
A (IQ)	1	3.35	29.75***
B (Pretest)	1	.17	1.53
C (Work Rate)	1	.56	4.93*
AB	1	.04	-
AC	1	.06	-
BC	1	.04	-
ABC	1	.13	1.18
Within Replicates	128	.11	

*significant beyond the .05 level
***significant beyond the .001 level

predictive, they do not tell the whole story. When the group of 312 Ss were categorized as falling into high, medium, and low groups both with respect to IQ and Errors, on the Force program approximately 13 percent of the high IQ Ss were characterized by high Errors. On the Atomics program, 8 percent were also so characterized. Moreover, approximately 7 percent of the high IQ group consistently appeared in the high Error grouping having appeared in the upper third or the high Error grouping on both programs.

As to the less able students, 13 percent of them were categorized in the low Error grouping on the Force program. On the Atomics program, 10 percent were similarly categorized. Approximately 7 percent of the low IQ Ss consistently fell into the bottom or low third of the Error distribution; that is, they appeared in that part of the distribution on both programs.

Programmed materials appear not to eliminate ability differences. High and low IQ students tend to distribute themselves (on Errors) much as they do on tests for conventional instruction. Some of them even tend to show an error pattern which is not predictable by ability considerations or by programming theory which, when programs are geared to the target population, calls for no performance differences (presumably save for Work Rate) as between ability levels. The high IQ, consistently high Error Ss constitute such a group. It is apparent therefore that other variables must be identified to account for additional variance in Errors.

Work Rate As a Predictor of Errors

In view of the findings on Work Rate which showed that many Ss did not work at a rate presumed to be appropriate to their ability level, Work Rate might be expected to influence Errors. Particularly, low IQ Ss who worked at a fast pace might be expected to have committed many errors. When Ss are characterized as high, medium, or low on IQ and on Work Rate for both programs, Error data for these breakdowns support this expectation. On the Atomics program, 59 percent of the low IQ Ss who were fast, committed a high number of Errors. On the Force program, 63 percent committed a high number of Errors. The corresponding percentages for the high IQ Ss who were fast were uniformly less than 10 percent. But, it should be added, approximately the same percentage of slow low-IQ Ss were

characterized by high Errors as were their fast low-IQ counterparts (approximately 63 percent of the group committed high Errors on both programs).

High Error rates for both fast and slow low-IQ Ss help explain the low positive, and in some instances non-significant, correlations between Work Rate and Errors reported earlier (see Table 3) and the minor predictive power Work Rate exhibits in regression analyses with Errors as criterion.

Referring back to the results of the variance analyses summarized in Tables 16 to 19, it can be seen that, as might be expected from the bimodal Error results for the slow low-IQ Ss, there was no significant interaction between IQ and Work Rate. However, these analyses generally reveal that fast Ss tended to commit more errors than did slow Ss ($P < .05$). This was true on both programs. Fast Ss committed 14 percent Errors, the slow Ss 11 percent on both programs. The magnitude of these overall differences is not high. But, as will be shown later, low IQ Ss contributed heavily to this finding and when fast and slow low-IQ Ss are compared, the effect of Work Rate on Errors increases substantially. The general findings, indicating that fast Ss tend to commit more errors, held up in one of two further analyses, to be discussed in the next section. There it will be noted that when fast and slow Ss were matched for Errors (on another program) as well as for IQ and Pretest, as they were here, fast Ss still committed more errors.

Work Rate appears to contribute to Errors but not in a uniform way, nor apparently as materially as IQ. As can be seen from Table 15, both together still do not account for more than 38 percent of the variance in Errors. The addition of Errors on another program however, can markedly increase the predictive power of the battery.

Errors on One Program as a Predictor of Errors on Another

The correlation between Errors on one program and Errors on another is nearly as high as the self-correlations found for Work Rate. The correlation for group I was $r = .73$ and for group II was $r = .83$. In the larger of these two groups ($N = 312$) approximately 68 percent of the entire group was consistent with respect to Errors on both programs. That is, when categorized as high, medium, or low on Errors on one program, they were identically categorized on the second. What should be of

particular concern to the programmer was the fact that 28 percent of the entire sample of 312 consistently made high Errors. Of this high Error group, approximately 8 percent had high IQs, 27 percent medium IQs and 65 percent low IQs.

Error rates are apparently stable characteristics of Ss. When a measure of it is taken on one program, it proves to be the best predictor of Errors on a second program. This can be seen from a reinspection of Table 15 where the addition of Errors to the battery increases the variance accounted for from an average of 38 percent to an average of 66 percent. Tables 20 to 23, beginning on page 33, show the beta weights (β) for each predictor and the unique portion of the variance accounted for by each separate predictor in the battery ($\beta.r$). While IQ makes a significant contribution, the major portion of the variance is accounted for by Errors on another program. This is further supported by the correlation observed between errors on the Atomics program and errors on the Force program. With IQ partialled out, the correlation is .55 for group I and .63 for group II.

The stability of error scores and their only moderate determination by IQ suggest that Errors may, like Work Rate, also reflect a student's stylistic work habits. In support of this view, it can be shown that, with three-way categories on both programs were filled on the basis of results both for Work Rate and for Errors, almost 50 percent of the entire sample consistently exhibited the same joint Work Rate and Error pattern on both programs. For example, approximately 6 percent of the entire sample could be characterized as fast Work Rate-high Error types, having been so categorized on the basis of their performance on both the Force and Atomics programs. Approximately the same percentage could be characterized as slow Work Rate-low Error types. Such consistent, joint Work Rate and Error patterns, not attributable to ability, suggest the possibility of characteristic or stylistic work habits in going through a program.

Table 20
 MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Errors on Atomics Program
 Predictor Variables: IQ, Pretest, Work Rate, and Errors
 Group I (N = 267) on other program

Intercorrelations						Mean	S.D.	N
	Errors X_1	IQ X_2	Pre- test X_3	W.R. Atomics X_4	Errors Force X_5			
Errors Atomics X_1		-.60	-.46	.25	.73	16.82	20.69	256
IQ X_2			.52	-.43	-.55	108.49	12.37	267
Pretest Atomics X_3				-.41	-.42	27.41	21.02	263
W.R. Atomics X_4					.23	46.11	8.01	258
Errors Force X_5						16.77	20.14	252

Regression Analysis					R^2 1.2345 = .601 R 1.2345 = .776 σ 1.2345 = 9.788
		β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
IQ X_2		-.245	-.599	.147	
Pretest Atomics X_3		-.120	-.465	.056	
W.R. Atomics X_4		-.035	.248	-.009	
Errors Force X_5		.555	.733	.407	

Table 21
 MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Errors on Atomics Program
 Predictor Variables: IQ, Pretest, Work Rate, and Errors
 Group II (N = 353) on other program

Intercorrelations						Mean	S.D.	N
	Errors X_1	IQ X_2	Pre- test X_3	W.R. Atomics X_4	Errors Force X_5			
Errors Atomics X_1		-.62	-.52	.16	.83	23.74	25.75	335
IQ X_2			.66	-.32	-.60	109.35	11.84	353
Pretest Atomics X_3				-.25	-.50	28.84	19.10	334
W. R. Atomics X_4					.07	47.59	9.22	335
Errors Force X_5						27.06	24.51	335

Regression Analysis					R^2 1.2345 = .722 R 1.2345 = .850 σ 1.2345 = 9.991
		β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
IQ X_2		-.126	-.622	.078	
Pretest Atomics X_3		-.066	-.520	.034	
W.R. Atomics X_4		.051	.160	.008	
Errors Force X_5		.722	.834	.602	

Table 22
 MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Errors on Force Program
 Predictor Variables: IQ, Pretest, Work Rate, and Errors on other program
 Group I (N = 267)

Intercorrelations						Mean	S.D.	N
	Errors X_1	IQ X_2	Pre- test X_3	W.R. Force X_4	Errors Atomics X_5			
Errors Force X_1		-.55	-.38	.18	.73	16.77	20.14	252
IQ X_2			.47	-.44	-.60	108.49	12.37	267
Pretest Force X_3				-.31	-.44	29.38	14.04	263
Work Rate Force X_4					.22	44.47	6.74	253
Errors Atomics X_5						16.82	20.69	256

Regression Analysis					R^2 1.2345 = .578 R 1.2345 = .760 σ 1.2345 = 9.871
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$		
IQ X_2	-.193	-.554	.107		
Pretest Force X_3	-.032	-.376	.012		
Work Rate Force X_4	-.049	.179	.009		
Errors Atomics X_5	.614	.733	.450		

Table 23
 MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Errors on Force Program
 Predictor Variables: IQ, Pretest, Work Rate and Errors on other program
 Group II (N = 353)

Intercorrelations						Mean	S.D.	N
	Errors X_1	IQ X_2	Pre- test X_3	W.R. Force X_4	Errors Atomics X_5			
Errors Force X_1		-.60	-.34	.04	.83	27.06	24.51	335
IQ X_2			.45	-.33	-.62	109.35	11.84	353
Pretest Force X_3				-.20	-.34	25.88	11.97	339
Work Rate Force X_4					.16	49.75	9.73	338
Errors Atomics X_5						23.74	25.75	335

Regression Analysis					R^2 1.2345 = .758 R 1.2345 = .871 σ 1.2345 = 8.798
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$		
IQ X_2	-.209	-.604	.126		
Pretest Force X_3	-.050	-.341	.017		
Work Rate Force X_4	-.238	.041	.010		
Errors Atomics X_5	.726	.834	.605		

Additional evidence showing the power of one measure of Errors to predict another, can be found in the variance analyses summarized in Tables 24 to 27 starting on page 36. (The analysis for the matching procedures appears in Tables 27 to 36 in Appendix B.) In these analyses, with Ss matched on the basis of the four variables, IQ, Pretest, Work Rate, and Errors on another program, Errors are by far the best predictor. High and low IQ Ss matched for Errors on one program no longer differ on Errors on the second program. On the other hand, even though matched for IQ, Pretest, and Work Rate, high and low Error Ss differ significantly ($P < .001$) on the dependent measure, Errors on the second program. Also, one of two analyses produced significant differences ($P < .05$) between fast and slow Ss, with fast Ss committing more Errors despite the fact that they were matched with their slow counterparts on all other variables. No significant interactions were found.

Summary

While it is true that ability and Errors are rather highly correlated, when the effects of IQ are partialled out, the correlations between Errors on one program and Errors on another, though not as high as those for Work Rate, remain relatively high ($r = .55$ for group I and $r = .63$ for group II). Error scores, therefore, appear to be relatively stable and also the best predictor of Error scores on other programs. Variables predictive of Errors in a given program in order of their predictive power, are Errors on another program, IQ, and Work Rate.

The relatively wide ability differences which exhibit themselves in Error scores, may in part be explained by the failure of students at various ability levels to select a pace presumed to be appropriate to those levels, particularly at the lower levels. Error scores also reflect the general effects of different pacing levels. With students otherwise matched for ability and even Errors on another program, fast students commit more errors than slow students.

Of particular interest to the programmer is the stable pattern of errors not attributable to ability. As in the case of Work Rate, students exhibit characteristic error patterns. These too may reflect characteristic work habits. Consistent high error performance may result from habits of

Table 24
Summary Results for Errors on the ATOMIC Program
by Levels of Each Independent Variable
(N = 80)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Errors		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	113.35	2.77	17.35	15.30	
	Low IQ	103.52	4.77	21.88	12.90	

B.	High Pretest (Force)	31.50	5.67	20.32	14.74	
	Low Pretest (Force)	16.60	4.11	18.90	13.89	

C.	Fast Work Rate (Atomics)	42.02	4.45	17.40	12.33	
	Slow Work Rate (Atomics)	53.95	3.32	21.82	15.78	

D.	High Errors (Force)	33.85	8.23	27.03	15.06	
	Low Errors (Force)	12.30	4.74	12.20	8.46	***

Table 25
Summary of the Analysis of Variance
for Errors on the ATOMICS Program
(N = 80)

Source	D.F.	Mean Squares	F
A (IQ)	1	409.51	2.69
B (Pretest [Force])	1	40.61	-
C (Work Rate [Atomics])	1	391.61	2.57
D (Errors [Force])	1	4395.61	28.84***
AB	1	66.61	-
AC	1	.31	-
AD	1	94.61	-
BC	1	365.51	2.40
BD	1	63.01	-
CD	1	74.11	-
ABC	1	10.51	-
ABD	1	17.11	-
ACD	1	122.51	-
BCD	1	177.01	1.16
ABCD	1	43.51	-
Within Replicates	64	152.45	

***significant beyond the .001 level

Table 26
Summary Results for Errors on the FORCE Program
by Levels of Each Independent Variable
(N = 96)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Errors		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	115.48	3.40	23.15	13.02	
	Low IQ	103.52	4.46	27.90	20.26	

B.	High Pretest (Atomics)	34.04	5.75	24.67	14.60	
	Low Pretest (Atomics)	15.71	5.41	26.38	19.41	

C.	Fast Work Rate (Force)	41.79	5.20	29.54	19.94	
	Slow Work Rate (Force)	55.12	4.46	21.50	12.68	*

D.	High Errors (Atomics)	31.25	12.34	32.23	16.19	
	Low Errors (Atomics)	9.70	3.52	18.81	15.41	***

Table 27
Summary of the Analysis of Variance
for Errors on the FORCE Program
(N = 96)

Source	D.F.	Mean Squares	F
A (IQ)	1	541.50	2.23
B (Pretest [Atomics])	1	70.04	-
C (Work Rate [Force])	1	1552.04	6.38*
D (Errors [Atomics])	1	4320.17	17.76***
AB	1	8.17	-
AC	1	294.00	1.21
AD	1	108.38	-
BC	1	376.04	1.55
BD	1	228.17	-
CD	1	54.00	-
ABC	1	400.17	1.64
ABD	1	1.04	-
ACD	1	108.38	-
BCD	1	280.17	1.15
ABCD	1	3.37	-
Within Replicates	80	243.18	

*significant beyond the .05 level.
***significant beyond the .001 level

quick problem solution, or careless reading habits, or failure to attend to confirmation frames. This latter conjecture is in part supported by data from the previous section on Work Rate, where high and low Error groups did not differ appreciably in the amount of time they took to complete the program. (If this is indeed a valid interpretation of the demonstrated high level of reliability of errors, not attributable to ability, the programmer would do well to exercise caution in treating error scores as a dependent measure to characterize program difficulty.)

The magnitude of the problem posed by the stability of error patterns, which perhaps tell at least as much about students as they do about the program, can be more fully assessed following an analysis of how errors, in turn, influence achievement.

Predictors of Achievement

Achievement is, of course, the programmer's ultimate goal, and it is therefore important to determine how achievement is affected by variations in the variables observed in this study. Answers to such practical questions as, should error rates be kept low, may be answered on the basis of data describing the empirically determined relationship between errors and achievement. Decisions as to whether to allow students to pace themselves must rely on data concerning the effect of work rate on errors and, if errors are indeed significant determiners of achievement, the resulting effect on achievement.

Correlations in Table 3 reveal something of the relationships between each of the several variables studied and Posttest scores. From the average values of the correlations presented there, it will be noted that, in descending order of magnitude, the variables correlating with Posttest are: Posttest score on another program ($r = .76$), IQ ($r = .69$), Errors ($r = -.66$), Pretest scores ($r = .51$) and Work Rate ($r = -.21$). Inspection of Table 28, presenting the coefficients of multiple determination (R^2) for various combinations of predictors, reveals that the combination of Errors, Pretest, and IQ accounts for a very sizeable portion of the variance in Posttest scores. From the average R^2 , it is apparent that this combination can account for approximately 60 percent of the variance in Posttest scores.

Table 28
Coefficients of Multiple Determination (R^2)
indicating the percentage of variance in Posttest Scores
associated with various combinations of predictor variables

<u>Predictor Variables</u>	<u>Force Program</u>		<u>Atomics Program</u>	
	<u>Group I</u>	<u>Group II</u>	<u>Group I</u>	<u>Group II</u>
Pretest + IQ	.507	.482	.528	.541
Errors + Pretest + IQ	.592	.564	.605	.632
Work Rate + Errors + Pretest + IQ	.594	.573	.606	.645
Reading Comp. + Work Rate + Errors + Pretest + IQ	.607	*	.636	*
Posttest + Work Rate + Errors + Pretest + IQ on other program	.647	.663	.672	.711

*Not obtained for Group II.

Each of the several variables will now be treated in detail with the effects of each assessed from results of both regression and variance analyses.

IQ and IQ-Related Variables as Predictors of Achievement

The goal generally set for programmed instruction of 80-90 percent achievement by 80-90 percent of the population receiving it can be attained only if the programming approach effectively absorbs or bridges ability differences. Evidence from research reports available to date indicate that this goal is not being universally met and suggests that perhaps inter-individual variability in achievement is due to ability differences even in programmed instruction. In the present study, the mean posttest score on both programs was approximately 75-80 percent with standard deviations of 20 percentage points. While both programs were well tried out and were also demonstrated capable of producing high average achievement results, considerable variability was evident. That ability differences influenced these results can be seen from the high IQ-Posttest correlations in Table 3, the average being $r = .69$. Thus, IQ alone was able to account for approximately 48 percent of the variance in achievement. The addition of Pretest scores, as shown in line 1 of Table 28, modestly increases the proportion of variance accounted for.

The relative power of IQ to predict Achievement when it is combined with other predictors, such as Reading Comprehension, Pretest Scores, Errors, and Work Rate can be seen from regression analyses summarized in Tables 29 and 30. The entire battery of predictors can account for approximately 62 percent of the variance. From the column labeled " $\beta.r$ " which indicates the percentage of the variance uniquely accounted for by each separate variable, it will be noted that IQ alone accounts for 21 percent of the variance, which, when added to the variance accounted for by the other variables in the battery, cumulates to the entire 62 percent of the variance accounted for. Along with Errors (which accounts for roughly the same percentage), IQ appears to be one of two major predictors of achievement.

Variance analyses confirm the effect of ability on achievement. Even when high and low IQ levels are matched for Pretest, Work Rate, and Errors, they still produce significantly different Posttest results. Despite the

Table 29

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Atomics Program
 Predictor Variables: IQ, Reading Comprehension, Pretest, Errors, and Work Rate
 Group I (N = 267)

Intercorrelations							Mean	S.D.	N
	Posttest Atomics X_1	IQ X_2	Read. Comp. X_3	Pretest Atomics X_4	Errors Atomics X_5	W.R. Atomics X_6			
Posttest Atomics X_1		.71	.65	.51	-.67	-.32	80.53	21.98	258
IQ X_2			.68	.52	-.60	-.43	108.49	12.37	267
Reading Comp. X_3				.50	-.48	-.33	12.54	4.12	258
Pretest Atomics X_4					-.47	-.41	27.41	21.02	263
Errors Atomics X_5						.25	16.82	20.70	256
Work Rate Atomics X_6							46.11	8.00	258

Regression Analysis				
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
IQ X_2	.298	.705	.210	R^2 1.23456 = .636 R 1.23456 = .797 σ 1.23456 = 13.27
Reading Comp. X_3	.240	.646	.155	
Pretest Atomics X_4	.086	.514	.045	
Errors Atomics X_5	-.342	-.673	.230	
Work Rate Atomics X_6	.012	-.317	-.004	

Table 30

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Force Program
 Predictor Variables: IQ, Reading Comprehension, Pretest, Errors, and Work Rate
 Group I (N = 267)

Intercorrelations							Mean	S.D.	N
	Posttest Force X_1	IQ X_2	Read. Comp. X_3	Pretest Force X_4	Errors Force X_5	W.R. Force X_6			
Posttest Force X_1		.69	.61	.48	-.65	-.34	76.22	19.28	252
IQ X_2			.41	.47	-.55	-.43	108.49	12.37	267
Reading Comp. X_3				.41	-.49	-.37	12.54	4.12	258
Pretest Force X_4					-.38	-.31	29.38	14.04	263
Errors Force X_5						.18	16.77	20.14	252
Work Rate Force X_6							44.47	6.74	253

Regression Analysis				
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
IQ X_2	.320	.691	.221	R^2 1.23456 = .607 R 1.23456 = .780 σ 1.23456 = 12.08
Reading Comp. X_3	.158	.606	.096	
Pretest Force X_4	.119	.475	.057	
Errors Force X_5	-.338	-.645	.218	
Work Rate Force X_6	-.046	-.343	.016	

fact that the entire group received relatively high average Posttest scores, as will be noted from Tables 31 to 34 starting on page 43, high IQ Ss still outperformed their low IQ counterparts by 6 percentage points ($P < .05$) on the Force program and by 10 percentage points ($P < .01$) on the Atomics program. These results are in agreement with the results of the regression analyses which described the importance of the role which IQ plays.

Pretest scores, as reflected in the regression analyses, account for a modest portion of unique variance associated with Posttest scores. One of the two variance analyses (with Ss at the high and low Pretest levels matched on IQ, Work Rate, and Errors), showed a significant superiority for the high Pretest group ($P < .001$), with the same trend in mean scores exhibited in the second analysis. Pretest, however, appears to make only a modest, independent contribution due to its apparently high correlation with IQ and Errors. (Tables 37 to 46 in Appendix B provide analysis of variance results concerning the matching process.)

As can be seen from the coefficient of multiple determination in Table 28, the entire battery accounts for approximately 62 percent of the variance in Posttest scores ($R^2 = .637$ and $.603$ on line 4). IQ and the IQ related variables, Pretest and Reading Comprehension, together account for approximately 39 percent of the variance (or 63 percent of the total variance accounted for). Thus, it is apparent that IQ and IQ related measures account for the most sizeable portion of variance in Posttest scores.

Errors as Predictors of Achievement

Errors were of concern to us earlier because the programmer treats them as a criterion measure to assess program difficulty and program adequacy. In connection with the latter purpose, it is important to treat errors also as a predictor, as a predictor of achievement, the programmer's ultimate goal. Programming theory, widely held, asserts that high achievement levels are contingent on low error rates, and, therefore, error rates should be kept as low as possible. It seems desirable to determine empirically whether and to what extent errors do in fact predict achievement, if efforts must be made to implement this theory.

Table 31
Summary Results for Achievement on the ATOMICS Program
by Levels of Each Independent Variable
(N = 112)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Posttest		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	115.27	3.12	81.54	17.02	**
	Low IQ	103.88	4.23	70.93	21.37	

B.	High Pretest	35.11	7.02	83.60	12.92	***
	Low Pretest	21.79	24.96	68.86	22.94	

C.	Fast Work Rate	40.80	5.20	72.14	23.03	*
	Slow Work Rate	54.02	4.97	80.32	15.47	

D.	High Errors	31.18	11.16	71.64	20.74	**
	Low Errors	9.84	4.18	80.82	18.71	

Table 32
Summary of the Analysis of Variance
for Achievement on the ATOMICS Program
(N = 112)

Source	D.F.	Mean Squares	F
A (IQ)	1	3150.32	10.81**
B (Pretest)	1	6091.75	20.89***
C (Work Rate)	1	1872.89	6.42*
D (Errors)	1	2358.89	8.09**
AB	1	92.89	-
AC	1	472.32	1.62
AD	1	.04	-
BC	1	540.32	1.85
BD	1	54.32	-
CD	1	211.75	-
ABC	1	8.04	-
ABD	1	1044.32	3.58
ACD	1	116.04	-
BCD	1	170.04	-
ABCD	1	43.74	-
Within Replicates	96	291.52	

*significant beyond the .05 level
 **significant beyond the .01 level
 ***significant beyond the .001 level

Table 33
Summary Results for Achievement on the FORCE Program
by Levels of Each Independent Variable
(N = 80)

		Separation Between Levels on Each Independent Variable		Results for Each Level on the Dependent Variable: Posttest		
		Mean	S.D.	Mean	S.D.	P
A.	High IQ	113.40	2.89	78.10	13.22	*
	Low IQ	103.70	4.87	71.90	15.06	

B.	High Pretest	31.80	5.43	76.20	14.17	
	Low Pretest	16.20	4.15	73.80	14.74	

C.	Fast Work Rate	42.60	4.39	71.80	13.97	*
	Slow Work Rate	56.60	5.04	78.20	14.32	

D.	High Errors	33.30	8.21	72.00	12.68	
	Low Errors	11.85	4.91	78.00	15.56	

Table 34
Summary of the Analysis of Variance
for Achievement on the FORCE Program
(N = 80)

Source	D.F.	Mean Squares	F
A (IQ)	1	768.80	4.21*
B (Pretest)	1	115.20	-
C (Work Rate)	1	819.20	4.49*
D (Errors)	1	720.00	3.94
AB	1	500.00	2.74
AC	1	135.20	-
AD	1	7.20	-
BC	1	460.80	2.52
BD	1	460.80	2.52
CD	1	12.80	-
ABC	1	20.00	-
ABD	1	64.80	-
ACD	1	231.20	1.27
BCD	1	204.80	1.12
ABCD	1	231.20	1.27
Within Replicates	64	182.50	

*significant beyond the .05 level

The average correlation obtained between Errors and Achievement, computed from the four relevant values appearing in Table 3, is $r = -.66$ (the range having been $r = -.65$ to $r = -.70$). These values are, needless to say, influenced by the relationship of both to IQ. With IQ partialled out, the range of correlations is $r = -.38$ to $r = -.48$, the average being $r = -.44$. Regression analyses just presented in Tables 28 and 29 further took into account the relationship between Achievement and other predictor variables. The average coefficient of multiple determination (R^2) was .62, with approximately .22 (or about one third) of this total attributable to Errors, an amount roughly equivalent to that contributed by IQ. While IQ and other IQ related measures account for approximately two thirds of the R^2 value, Errors account for the remaining third.

The variance analyses summarized in Tables 31 to 34 partially confirm the same important role for Errors. Even when high and low Error Ss are matched for IQ, Pretest, and Work Rate, Ss who committed a small number of Errors outscored their high Error counterparts by roughly 9 percentage points on the Atomics program ($P < .01$) and 6 percentage points on the Force program (just falling short of significance at the 5 percent level. Thus, while the overall achievement level for the entire group was quite high, variations in Error rate still produced differences in Achievement.

In a recent paper, Klaus (1964) reported a correlation between error rate and achievement of $-.29$. Since both vary with ability level, high and low error groups were then matched for ability and only one of four t-test comparisons showed significantly higher achievement for the low error group. The highest mean error rate reported for one of the experimental conditions in the Klaus study did not, however, exceed 13 percent. Thus, as Klaus pointed out, error rates may have been too low to have materially influenced achievement.

In the present study the mean Error rate for the high Error group was somewhat higher than the Klaus figure. The mean "high Error" rate for the group was approximately 18 percent with an average standard deviation of 5 percent. This group scored significantly lower on Posttests than their low Error counterparts. It is possible to say, therefore, that programming theory which recommends low error rate as the path to high achievement does find empirical support in both the regression and variance analyses presented here.

Work Rate as a Predictor of Achievement

In view of the sizeable role that errors play in determining achievement, it would be expected that Work Rate would affect Achievement inasmuch as Work Rate and Errors had also been shown to be related. However, with Errors in a battery of predictors, Work Rate, as can be seen from the coefficients of multiple determination (Table 28) and from beta (β) and $\beta.r$ values (Tables 29 and 30), appears to account for negligible amounts of unique variance in Achievement. This does not seem too surprising in view of the relatively low correlations between Work Rate and Achievement (the four obtained values being $r = -.34$ and $r = -.09$ for the Force program and $r = -.32$ and $-.12$ for the Atomics program). The variance analyses (Tables 31 to 34), on the other hand, show significantly superior performance for slow Ss, even when fast and slow Ss are matched for Errors (and for IQ and Pretest). Slow Ss scored 8 percentage points higher ($P < .05$) on the Atomics program and 7 percentage points higher ($P < .05$) on the Force program.

In another variance analysis of Posttest scores, not reported until this point, fast and slow Ss were matched for Pretest and IQ but Errors were left free to vary. (These analyses and the results of the matching process involved are summarized in Tables 47 to 58 in Appendix B.) From these analyses, it was observed that the Work Rate x IQ interaction was significant ($P < .05$) for the Force program and approached significance for the Atomics program. Since both trends are so highly similar, it is instructive to plot the posttest scores for the Work Rate x IQ interaction. As can be seen from Fig. 4 and 6 on page 47, the significant differences in Achievement which have been reported between fast and slow Ss quite obviously derive principally from the results of fast and slow low-IQ Ss. Among low IQ Ss, those who are fast scored substantially lower than their slow counterparts. In a similar analysis reported earlier in the discussion of Errors, Error data for Work Rate x IQ interactions (although not statistically significant) show the expected reverse results. As seen in Fig. 3 and 5, slow low-IQ Ss made fewer Errors than their fast counterparts. The differences between fast and slow low-IQ Ss are evident both on Errors and Posttest scores.

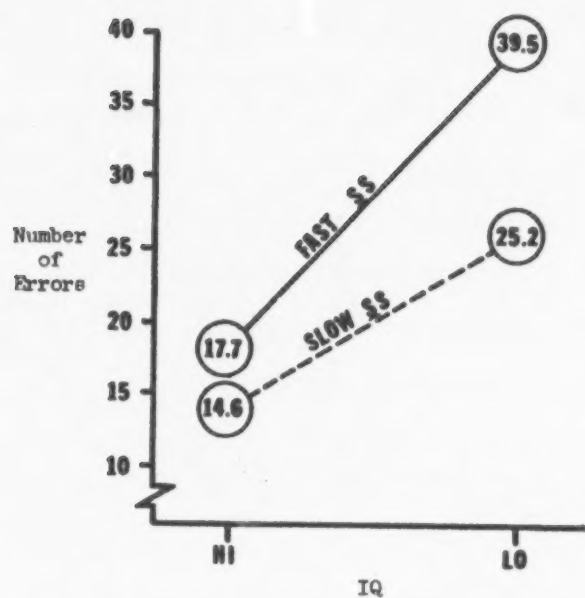


Figure 3

The interactive effect of Work Rate and IQ on Errors (Force Program)

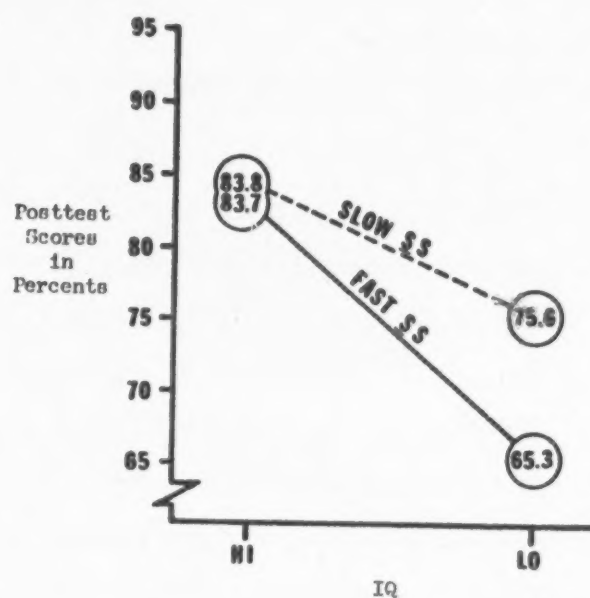


Figure 4

The interactive effect of Work Rate and IQ on Achievement (Force Program)

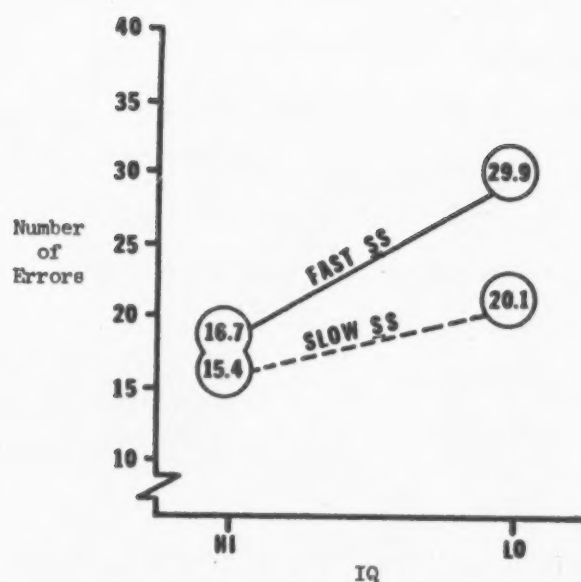


Figure 5

The interactive effect of Work Rate and IQ on Errors (Atomics Program)

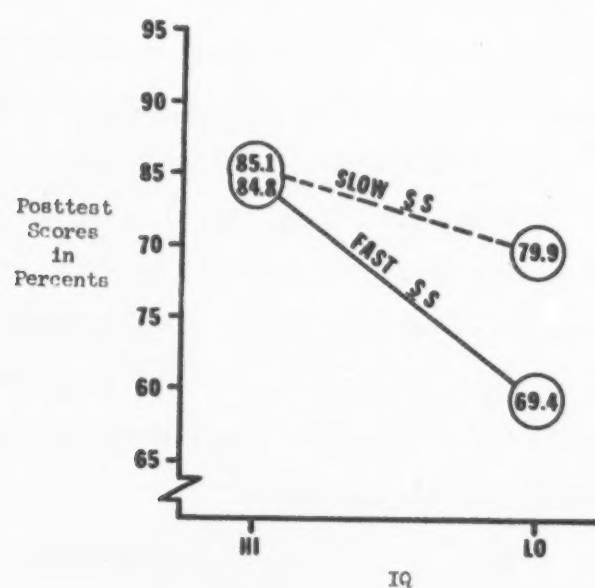


Figure 6

The interactive effect of Work Rate and IQ on Achievement (Atomics Program)

As will be remembered from the discussion of Errors, fast Ss in general tended to make more errors than did slow Ss. The data on Achievement parallel this finding, with fast Ss receiving lower Posttest scores. It appears that the most sizeable contribution to this finding is made by low IQ Ss.

The two programs used in this study were capable of producing high level achievement even among low IQ students. Approximately one third of the low IQ group (the bottom half of the distribution) scored 80 percent or better on achievement tests for the Atomics program. Approximately 27 percent of the low IQ group scored 80 percent or better on Achievement tests for the Force program. It is instructive to note that of those low IQ Ss who reached this standard, 65 percent worked at a slow rate (bottom half of the Work Rate distribution) on the Atomics program and 74 percent worked at a slow rate on the Force program.

Bar graphs in Fig. 7 and 8 further illustrate how variations in Work Rate among low IQ Ss affected their performance. These figures indicate the percentage of low IQ Ss at a given Work Rate level who met the often prescribed standard of 10 percent (or lower) error rate and 80 percent (or better) achievement. As can be noted, there is a modest, reasonably uniform, and increasing tendency for these standards to be met as Work Rate becomes slower. On the Force program, the bimodal results for low IQ Ss alluded to earlier appears once again. Generally, the slower the Work Rate low IQ students assumed, the more frequently did they reach prescribed standards. However, fewer of the very slowest low-IQ students reached the prescribed standards. This is not likely to be due to the fact that they worked at a slow rate. It is more likely to be the case that those who are the very slowest are so because they are not able to meet the standards.

When low IQ Ss do work at a rate which is thought to be in keeping with their ability and with their needs, they are more likely to meet the standards set for programmed instruction. When left to their own devices, however, many of them fail to work at an appropriate rate, with resulting decrements in performance.

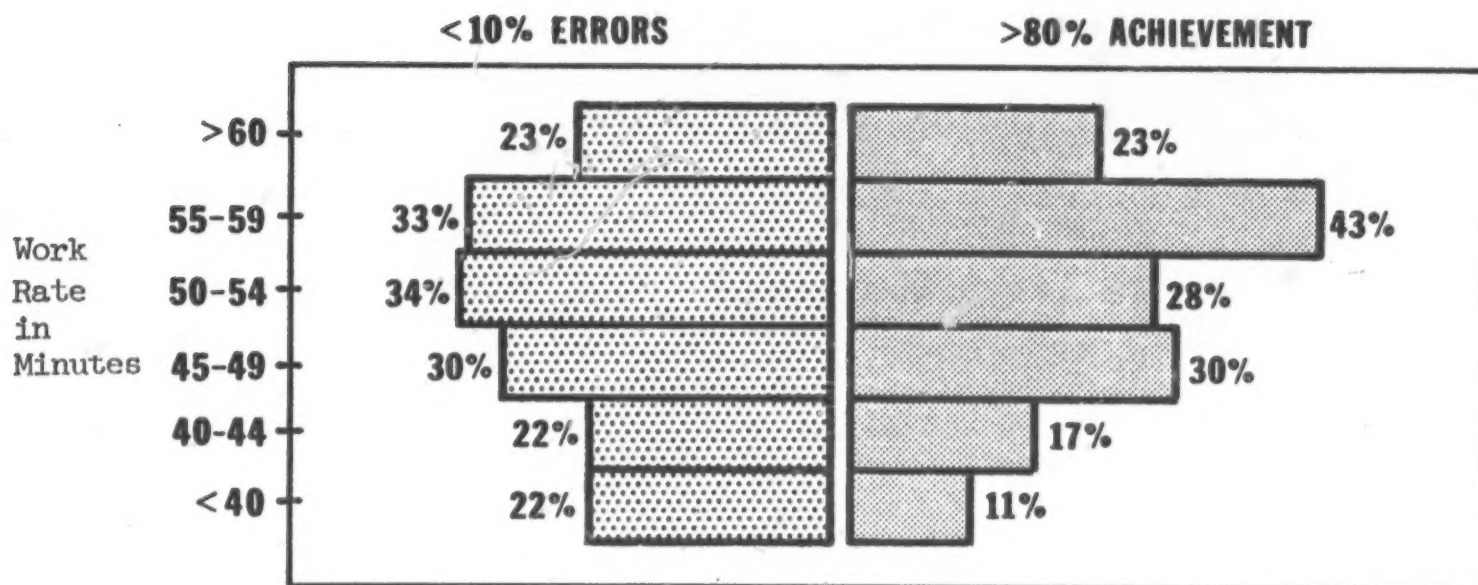


Figure 7

Percentages of LOW IQ Ss within each Work Rate Level
reaching Prescribed Performance Criteria
(Force Program)

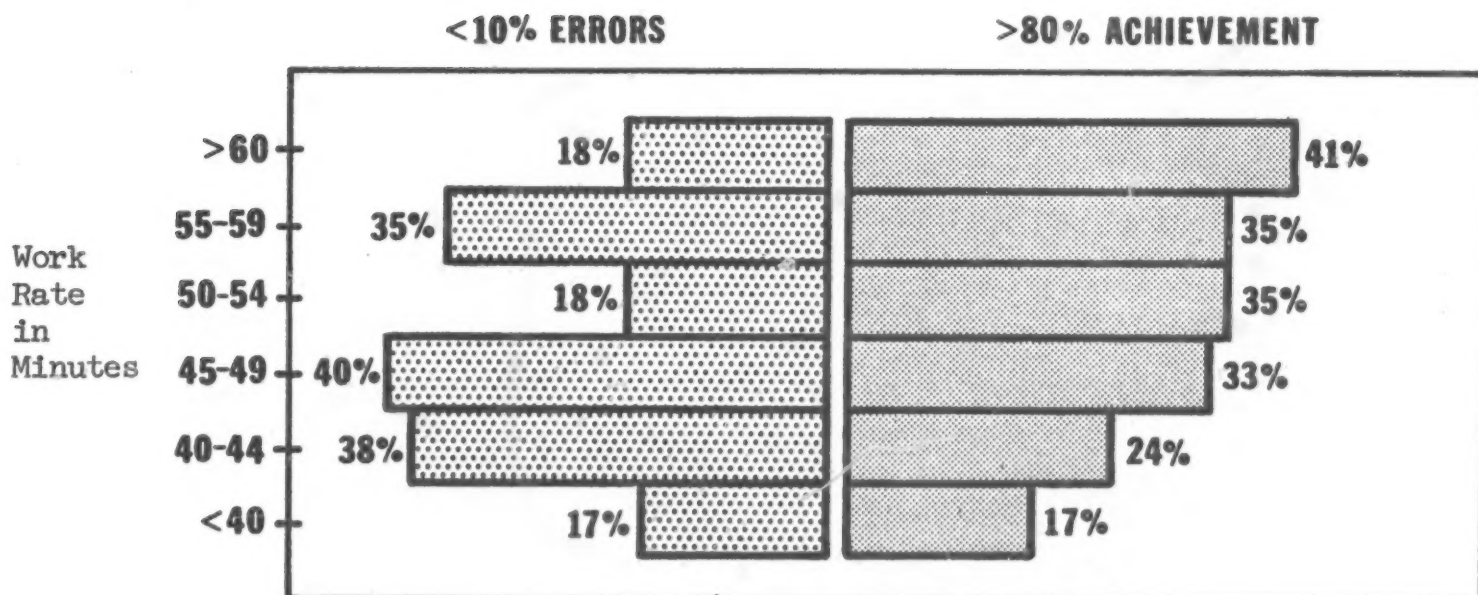


Figure 8

Percentages of LOW IQ Ss within each Work Rate Level
reaching Prescribed Performance Criteria
(Atoms Program)

Achievement on One Program as a Predictor of Achievement on Another

The data in this study suggest a relatively stable achievement level for both programs which is not predicted by ability. The correlations between Posttest scores on the two programs are $r = .74$ for group I and $r = .77$ for group II. Partialling out IQ, which is highly related to both, these correlations decline substantially but remain fairly high, $r = .51$ and $r = .56$ for the two groups studied. Regression analyses, which held variables other than IQ constant, also testify as to the high predictive power of achievement on one program in predicting achievement on another. Results in Tables 35 to 38 indicate that when Posttest scores on one program are included in a battery that already contains Work Rate, Errors, Pretest, and IQ, they earn the highest predictive weight. The average R^2 for this combination of predictors is .67 (accounting for 67 percent of the variance in Posttest scores). Posttest scores (on another program) contribute most heavily to this total. The average β .r values (which cumulate to make up R^2) are .30 for Posttest scores, .15 for IQ, and .15 for Errors (with Pretest and Work Rate making up the remaining .07 of the total R^2 of .67).

Posttest score seems to be a moderately stable measure and to account for the most sizeable portion of variance in Posttest scores on another program, a portion not attributable either to IQ or to Errors or the remaining variables in the battery. While Posttest scores are neither as stable as Work Rate or Errors nor as predictive of its counterpart on another program (as Work Rate and Errors are in predicting their counterparts on another program), they perhaps do represent a stylistic performance characteristic. A good deal of this stylistic performance may be attributable to attitudes toward-test taking. Or it may be attributed to test-taking behavior, for example, skill in taking a test or work habits in answering test items. The Tate findings on stability of response speed in test-taking provide some support for this interpretation.

Summary

In a relatively heterogeneous group, achievement appears to be a function of ability. Even when it is produced through programmed instruction, and programs are geared to the target population, it is also influenced by the number of errors committed in working through a program.

Table 35

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Atomics Program
 Predictor Variables: Posttest, IQ, Pretest, Work Rate, and Errors
 Group I (N = 267)

Intercorrelations							Mean	S.D.	N
	Posttest Atomics X_1	Posttest Force X_2	IQ X_3	Pretest Atomics X_4	W.R. Atomics X_5	Errors Atomics X_6			
Posttest Atomics X_1		.74	.70	.51	-.32	-.67	80.53	21.98	258
Posttest Force X_2			.69	.48	-.39	-.59	76.22	19.28	252
IQ X_3				.52	-.43	-.60	108.49	12.37	267
Pretest Atomics X_4					-.41	-.46	27.41	21.02	263
Work Rate Atomics X_5						.25	46.11	8.01	258
Errors Atomics X_6							16.82	20.69	256

Regression Analysis				R^2 1.23456 = .672 R 1.23456 = .820 σ 1.23456 = 9.319
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
Posttest Force X_2	.381	.741	.282	
IQ X_3	.257	.705	.181	
Pretest Atomics X_4	.095	.514	.049	
Work Rate Atomics X_5	.046	-.317	-.015	
Errors Atomics X_6	-.260	-.673	.175	

Table 36

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Atomics Program
 Predictor Variables: Posttest, IQ, Pretest, Work Rate, and Errors
 Group II (N = 353)

Intercorrelations							Mean	S.D.	N
	Posttest Atomics X_1	Posttest Force X_2	IQ X_3	Pretest Atomics X_4	W.R. Atomics X_5	Errors Atomics X_6			
Posttest Atomics X_1		.77	.69	.64	-.12	-.70	76.06	24.85	335
Posttest Force X_2			.68	.56	-.09	-.65	73.08	19.78	337
IQ X_3				.66	-.32	-.62	109.35	11.84	353
Pretest Atomics X_4					-.25	-.52	28.84	19.10	334
Work Rate Atomics X_5						.16	47.59	9.22	335
Errors Atomics X_6							23.74	25.75	335

Regression Analysis				R^2 1.23456 = .711 R 1.23456 = .843 σ 1.23456 = 9.841
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
Posttest Force X_2	.400	.773	.309	
IQ X_3	.146	.692	.101	
Pretest Atomics X_4	.213	.645	.137	
Work Rate Atomics X_5	.060	-.116	-.007	
Errors Atomics X_6	-.244	-.699	.171	

Table 37

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Force Program
 Predictor Variables: Posttest, IQ, Pretest, Work Rate, and Errors
 Group I (N = 267)

Intercorrelations							Mean	S.D.	N
	Posttest Force X_1	Posttest Atomics X_2	IQ X_3	Pretest Force X_4	W.R. Force X_5	Errors Force X_6			
Posttest Force X_1		.74	.69	.48	-.34	-.64	76.22	19.28	252
Posttest Atomics X_2			.70	.39	-.28	-.70	80.53	21.98	258
IQ X_3				.47	-.44	-.55	108.49	12.37	267
Pretest Force X_4					-.31	-.38	29.38	14.04	263
Work Rate Force X_5						.18	44.47	6.74	253
Errors Force X_6							16.77	20.14	252

Regression Analysis				R^2 1.23456 = .647 R 1.23456 = .805 σ 1.23456 = 8.522
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
Posttest Atomics X_2	.372	.741	.276	
IQ X_3	.231	.691	.160	
Pretest Force X_4	.126	.475	.060	
Work Rate Force X_5	-.065	-.343	.022	
Errors Force X_6	-.200	-.645	.129	

Table 38

MULTIPLE REGRESSION ANALYSIS
 Criterion Variable: Posttest on Force Program
 Predictor Variables: Posttest, IQ, Pretest, Work Rate, and Errors
 Group II (N = 353)

Intercorrelations							Mean	S.D.	N
	Posttest Force X_1	Posttest Atomics X_2	IQ X_3	Pretest Force X_4	W.R. Force X_5	Errors Force X_6			
Posttest Force X_1		.77	.68	.42	-.09	-.65	73.08	19.78	337
Posttest Atomics X_2			.69	.42	-.09	-.65	76.06	24.85	335
IQ X_3				.45	-.33	-.60	109.35	11.84	353
Pretest Force X_4					-.20	-.34	25.88	11.97	339
Work Rate Force X_5						.04	49.75	9.73	338
Errors Force X_6							27.06	24.51	335

Regression Analysis				R^2 1.23456 = .663 R 1.23456 = .814 σ 1.23456 = 8.525
	β_{1k}	r_{1k}	$\beta_{1k}r_{1k}$	
Posttest Atomics X_2	.467	.773	.361	
IQ X_3	.228	.681	.155	
Pretest Force X_4	.068	.425	.029	
Work Rate Force X_5	.047	-.093	-.064	
Errors Force X_6	-.188	-.650	.122	

Because of this relationship and of the effect that Work Rate has on Errors, Work Rate also appears to determine achievement level. The slower it is, particularly for low IQ students, the more likely is higher achievement to result. But, achievement levels also seem to reflect stylistic performance perhaps related to test taking skills or to work habits employed in taking tests.

CONCLUSION

Conventional instruction and programmed instruction both must cope with vexing problems posed by human variability. Both must create learning experiences that, when completed, will have taken initially wide inter-individual differences and reduced them to acceptable proportions. Conventional instruction has tolerated, and even institutionalized with grading systems, a high degree of terminal inter-individual differences. Programmed instruction, on the other hand, has more ambitiously sought to reduce variability in achievement among students by setting as its goal 80-90 percent achievement for 80-90 percent of the population receiving it. The primary means for achieving this goal has been systematic control over the student's learning behavior. One approach which has been relied on to realize this goal has been that of providing the same specially prepared materials to all students but abandoning some degree of control and allowing the individual student in using them to work at his own pace. Inter-individual differences in work rate, it was felt, would parallel and adequately reflect differences among students in ability, thereby making the learning experience provided them assimilable by all. Also implicit in the view that self-pacing could contribute to the reduction of inter-individual differences in terminal achievement is the assumption that systematic intra-individual differences in work rate would parallel and reflect variations in experienced difficulty. The evidence collected in this study casts some doubt on both these expectations. This evidence will be traced and reviewed in a discussion of several interrelated problems, including: (1) the effect of errors on achievement; (2) the effect of self-pacing on performance; (3) self pacing as an accommodation of individual differences in ability; and (4) the stability of Work Rate, Errors, and Achievement.

Effect of Error Rate on Achievement

It is well to start with "achievement," for it is the educator's ultimate goal and, as a result, the ultimate evidence as to whether variations in the content or format of programmed instruction and in its administration are successful. Student error rates on the program provide intermediate evidence of its success. Whether to allow this intermediate evidence to stand for or replace achievement as a criterion of program adequacy is not at issue among programmers. There is widespread agreement that both are needed. What is at issue is whether error rates should be kept low in order to insure high achievement. Arguments on one side hold that the practice of errors interferes with learning (Skinner, 1954; Holland, 1960); on the other, that learning can be enhanced by the opportunity to emit unreinforced error responses (Amsel, 1960). Thus, empirical evidence as to the relationship between errors and achievement is necessary if these conflicting views are to be resolved.

Based on the evidence of the present study, it appears that Ss who make fewer errors, regardless of ability level, tend to score higher on achievement tests. Errors and achievement are related to a moderately high degree even when ability, work rate, and levels of entering knowledge are controlled. This evidence provides convincing support for the position that errors are best kept low to insure high achievement.

The evidence collected in this study is not relevant to the question of what the programming approach should be if error rate is to be kept low. (There is a reasonable consensus that it is not to be accomplished through over-prompting (Krumboltz, 1964).) It is relevant, however, to questions having to do with the role of self-pacing. For, if an increasing number of errors leads to lower achievement, as they were shown to do here, it is important to determine whether allowing the student to pace himself represents the best administrative strategy to insure appropriately low error rates.

Effects of Self-Pacing on Performance

The effects of Work Rate on performance are neither as clearly nor as uniformly revealed by the present data as might be wished. Correlational and regression analysis failed to reveal any substantial relation between

the two. Variance analyses, however, demonstrated that work rate affected both errors and achievement. Moreover, interactions between IQ and work rate revealed in these latter analyses helped explain the low relations between work rate and performance observed in the regression analyses. Thus, interactions detectable in the variance analyses but not detectable in the regression analyses, where each predictor is merely analyzed with the effects of the other predictors held constant, provide a more informative picture of the effect of work rate on performance. While significant interactions were not obtained uniformly, the trends observed do hold up uniformly and help clarify the effect that work rate has on performance.

On tried-out programs, it might be expected that there would not be differences in errors or in achievement between groups who worked at a fast or at a slow pace. Ideally, each pace is appropriate to the needs of those adhering to it. The main effect observed, however, was that students whose self-selected rate was "fast" generally made more errors and scored lower on posttests than did their slower counterparts. Since the fast and slow groups were matched for ability and prior knowledge, these effects appear to be directly attributable to the rate or pace at which students worked through the programs.

The interactions observed, however, indicated that most of this effect was due to variations among low IQ students. While there was relatively little difference in performance among high IQ students who either worked at a slow or at a fast pace, there were substantial differences among low IQ students who worked at slow pace and low IQ students who worked at a fast pace. Much in keeping with programming theory, the pace high IQ students select, whether fast or slow, leads to uniformly high achievement. Not in keeping with programming theory, however, are the findings for low IQ students, precisely the group programming theory asserts needs the benefit of the extra time self-pacing is supposed to provide. Superior performance was observed for those low IQ students who did work at a slow rate. But low ability students in substantial numbers work at a rate apparently too fast to permit low-error, high-achievement performance. Thus, low IQ students neither perform as well as their high IQ fellows nor do they perform at a uniform level among themselves. Questions therefore arise as to the wisdom of allowing all students to pace themselves as a means of accommodating individual differences in ability.

Accommodating Individual Differences Through Self-Pacing

If "self-pacing" is to be judged capable of serving effectively as a mechanism for accommodating individual differences in ability, a first consideration is the way in which student work rate scores distribute themselves. There is little question about the high degree of inter-individual variability in work rate which students do display either in already published research or in this study. On both programs in the present study, the lower and upper scores bracketing just the middle 64 percent of the sample were almost in the ratio of one and a half to one with the slowest students in this group taking roughly 55 minutes, the fastest taking roughly 38 to 40 minutes. The slowest students on the entire distribution took more than twice as much time as the fastest students. If self-selected work rate does not to a sufficient degree accommodate individual differences in ability, it cannot be said to be due to lack of variability in its distribution. There is sufficient range of inter-individual variability in work rate to match or to reflect inter-individual variability in ability.

But, while work rate and ability varied independently to a high degree, they varied together to only a moderate degree. Too many high ability students work at a pace which may be inefficient for them, although it certainly allows them to reach high achievement levels. Perhaps more seriously, too many low ability students work at a pace which is too fast for them to allow 80-90 percent achievement. Also, too many students who commit a relatively high number of errors apparently fail to moderate their pace in keeping with the difficulties they obviously experience.

Thus, allowing students to retain control over their own pacing requirements, leads to work rates which, while exhibiting substantial inter-individual variability, fail to eliminate inter-individual variability in performance. Differences in ability, prior knowledge, and experienced difficulty are not fully discounted even though programs are tried out and students allowed to pace themselves. Self-selection of work rate appears to be non-adaptive for many students and the particular rate assumed appears to be for many students more closely linked with and predicted by non-ability variables.

Stability of Work Rate, Errors, and Achievement

One of the most striking findings of this study is the consistency of students from program to program on all three performance variables: Work Rate, Errors, and Achievement. The relationship between a measure of Work Rate on one program and Work Rate on another is quite high. A similar but slightly lowered relationship holds for Errors on one program and Errors on another. The same is true for Achievement, but to a markedly smaller degree. These relationships remain strong even when the effect of ability and prior knowledge of subject matter is controlled. The extent of such consistency can be seen even more clearly in the tendency of students to exhibit similar combined Work Rate and Error patterns on both programs. Fifty percent of the sample in the present study exhibited the same combined Work Rate and Error pattern on the second program as they did on the first. It is only because of this measure of reliability, that it is possible for each of these performance variables to be even modestly predicted by other individual difference variables.

The high reliability of these performance measures and their high self-predictive power (relative to other measures and with these other measures controlled) suggest that they all reflect a stylistic or characteristic performance. Each student appears to work at a rate that is characteristic of him. Relatively independent of his ability and of the difficulty he experiences, his work rate, it is interpreted, reflects his characteristic reading speed and his characteristic work habits. The work habit interpretation is supported by the findings of consistent error patterns and of consistent, joint work rate and error patterns. Students can race through programmed materials or work at a deliberate pace. They can toss off their answers or ploddingly compose and record them. Which-ever they do on one program, they appear to repeat in similar fashion on the second program. These findings suggest that one of the reasons work rate does not bridge individual differences in ability is that students work at a rate which appears to be less than completely determined by the learning task or by success or failure in accomplishing it.

Implications

If programmed instruction is to succeed in substantially reducing inter-individual differences in terminal achievement, as conventional instruction has not been able to do, it would seem desirable that control be exercised over student learning behavior to a far greater degree than is now being done. Only those students who demonstrate on screening programs that they can work at a pace which permits them to reach satisfactory achievement levels should be permitted to pace themselves. Those who do not, should, perhaps, have a pace determined for them. This, of course, would most likely be the case for low IQ students who work too fast. On the other hand, high IQ students who work slowly, might be successfully speeded up. The results in this report have only described, after the fact, what happens when students attempt to learn at a self-selected pace. They provide no experimental evidence, which is necessary to answer the questions just raised, as to whether externally controlled pacing will remedy the problem. Reports #2 and #3 (Kress & Gropper, 1964a,b) deal with this latter approach. The evidence here does suggest, however, that when low ability students do work at a pace appropriate to their ability level they are more likely to reach high achievement levels. However, allowing students to retain control over the rate at which they work does not invariably result in optimal selection of work rate. The consequence of this fact is that optimal achievement is not attained by all.

No conclusive statement can be made at this time about the generality of these findings. They are based on the performance of eighth-grade students who are apt to be more heterogeneous in ability than the more highly screened college population and perhaps less heterogeneous than grade-school students. Whether older students or adults who have survived additional selection processes work at a more adaptive pace, remains to be determined empirically. Among younger students, it might be conjectured, self-selection of work rates is likely to be no more adaptive, and perhaps even less so. This also is important to determine empirically.

These results have implications not only for the kinds of research issues concerning self-pacing which merit investigation. They also suggest serious reconsideration of work rate as a dependent variable in research concerned with other programming issues. Since work rate appears to be a

highly stable characteristic of individuals, caution appears warranted when work rate is treated as a dependent variable in assessing the effects of variations made in program variables. Either systematic, prior matching of Ss for characteristic work rate or subsequent tests for the matching of Ss by random assignment should be performed. Otherwise, significant differences between groups with respect to work rate may be spurious, simply reflecting differences in work rate which existed before experimental treatments were initiated. Moreover, given the apparent, relatively stable nature of work rate, it may be unduly optimistic to expect changes in it to occur as a result of experimental manipulations. Whenever subjects are in fact matched for work rate and differences between experimental treatments can still be shown, rather persuasive arguments may be warranted regarding the potency of experimental treatments.

The findings of non-adaptive work rates exhibited by sizeable numbers of low ability students also have implications for strategies of program preparation, tryout, and revision. Common practice among programmers is to make revisions in programmed lessons, often quite drastic in scope, when high errors are found in tryouts. Changes which are made generally reduce a program's step-size making it more assimilable to lower ability students. This approach generally assumes that the self-selected pace is appropriate but that the cuing level of the program is inadequate. Changes made, based on this assumption, usually result in a program geared often to the lower end of the ability distribution. In view of the findings presented here, it is not unreasonable to speculate that efforts to make programs more effective should as much revolve around pacing failures as around step-size considerations. They should, perhaps, include control over student pacing. This approach might result in programs geared at somewhat higher ability levels than is currently customary. This would be a step in the direction of not confusing student failures in pacing with the programmer's failure in program preparation. The more laborious task of revising programs might best be postponed until it is determined that high error rates and insufficiently high achievement is not due first of all to pacing problems. Substantial improvement in achievement may be realized before revision is even attempted by simply requiring students to assume a pace

more appropriate to their needs. Thus, control over work rates would be exercised for those students who demonstrate a need for it.

The results concerning error patterns also suggest that perhaps more control needs to be exercised over student work habits. It may be desirable to exercise control over more than just the rate at which a student works. In view of the consistency of error patterns, it seems worthy of investigation to determine whether it is appropriate for high error students, whose errors are not predicted by the usual ability measures, to be required to monitor their own error responses. Monitoring behavior, at its simplest, might consist of discriminating between responses which are correct and those which are incorrect. In essence, this means paying more attention to confirmation frames than many students now do and recognizing whether there is a difference between their own recorded answer and the printed answer on the page. Even at this level of monitoring, cavalier disregard of confirmation or a committed error can be discouraged. If such control over learning behavior resulted in decreasing numbers of errors as a student continued to work on a program, improved achievement levels would be made more likely.

Self-monitoring behavior can be facilitated when programmed booklets are used by requiring the student to indicate with an X on a confirmation page whether his answer was different from the printed, correct answer and hence incorrect. This can also be readily accomplished with automated devices. Students can be made to continue responding until they do so correctly. The device can be programmed not to produce the next frame until students do respond correctly, as with early disc devices used at Harvard. Whatever the mechanism, student's attention to the fact that he is committing errors can be better controlled.

The protagonists of programmed instruction, particularly the behaviorists among them, attribute much of its success to the high degree of control exercised over the conditions under which response is made to follow stimulus and reinforcement to follow both. Antagonists are apt to chafe over precisely this measure of control. The evidence cited in this study appears to support the hypothesis that even more, not less, control is needed. Specifically, those students who work at non-adaptive rates might be required to work under fixed-paced conditions selected for them.

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APPENDIX A

Programmed Materials and Tests

	<u>Page</u>
1. Preliminary Programs	
A. Preliminary program I: How to go through a program	A-1
B. Preliminary program II.	A-6
2. Experimental Programs	
A. Atomics program	A-26
B. Force program	A-33
3. Achievement Tests	
A. Atomics test (parts I & II)	A-41
B. Force test	A-43

PRELIMINARY PROGRAM I: HOW TO GO THROUGH A PROGRAM*

You are going to learn in a new way from a special sort of lesson, called a "program." Turn to the next page to begin.

This is Step 1.

You can learn from this step if you fill in the blank below with an answer. Here is a blank space for you to write your

(write the word "answer" in this space)

Now turn to the next page, which is called the check page.

Check Page 1.

You should have filled in the blank space in step 1 on the previous page with the word "ANSWER."

TURN TO STEP 2.

Step 2.

If you read carefully and try hard, you should get the correct _____ to nearly every step.

Turn to the next check page.

Check Page 2.

If you read carefully and try hard, you should get the correct ANSWER to nearly every step.

TURN TO STEP 3.

Step 3.

Each time you complete a step, you turn the page to check if you have the right _____. By turning the page you can _____ your _____.

Check Page 3.

Each time you complete a step, you turn the page to check if you have the right ANSWER. By turning the page you can CHECK your ANSWER.

Step 4.

Carefully reading the check page is the best way to _____ your _____.

Check Page 4.

Carefully reading the check page is the best way to CHECK your ANSWER.

Step 5.

When you see a single blank space, you only have to write one word. Here, you only have to write _____ word.

Check Page 5.

When you see a single blank space, you only have to write one word. Here, you only have to write ONE word.

Step 6.

Whenever you see a blank space you will have to write an _____ which contains only _____ word.

Check Page 6.

Whenever you see a blank space you will have to write an ANSWER which contains only ONE word.

*Each frame (step) appeared on a separate page. Its confirmation (check page) appeared on the following, separate page with the stem repeated and the correct answers supplied in capital letters.

Step 7.

A space with a star like the one below means the answer consists of more than one word. Here, for example, the answer consists of * _____.

Check Page 7.

A space with a star like the one below means the answer consists of more than one word. Here, for example, the answer consists of MORE THAN ONE WORD.

Step 8.

Sometimes, answers consist of only _____ word, but sometimes they consist of * _____.

Check Page 8.

Sometimes, answers consist of only ONE word, but sometimes they consist of MORE THAN ONE WORD.

Step 9.

A one word answer must be exactly the same as the answer on the check page. An answer that consists of more than one word must also be _____ the _____ as the * _____.

Check Page 9.

A one word answer must be exactly the same as the answer on the check page. An answer that consists of more than one word must also be EXACTLY the SAME as the ANSWER ON THE CHECK PAGE.

Step 10.

Reading each step carefully will help you write an _____ that is * _____ as the * _____.

Check Page 10.

Reading each step carefully will help you write an ANSWER that is EXACTLY THE SAME as the ANSWER ON THE CHECK PAGE.

Step 11.

When you see a plain space (____), you answer with _____ word. Your answer must be * _____ as the * _____.

Check Page 11.

When you see a plain space (____), you answer with ONE word. Your answer must be EXACTLY THE SAME as the ANSWER ON THE CHECK PAGE.

Step 12.

When you see a space with one star (*____), your answer consists of more * _____. It must be * _____.

Check Page 12.

When you see a space with one star (*____), your answer consists of more THAN ONE WORD. It must be EXACTLY THE SAME AS THE ANSWER ON THE CHECK PAGE.

Step 13.

When you see two stars (**____), you may answer in your own words, if you like. Two stars mean ** _____.

Check Page 13.

When you see two stars (**____), you may answer in your own words, if you like. Two stars mean YOU CAN GIVE THE ANSWER IN YOUR OWN WORDS IF YOU LIKE.

Step 14.

Even when the answer is in your own words, it should mean the same as the answer on the check page. An answer to a ** space should _____ the _____ as the answer on the * _____.

Check Page 14.

Even when the answer is in your own words, it should mean the same as the answer on the check page. An answer to a ** space should MEAN the SAME as the answer on the CHECK PAGE.

Step 15.

You may answer in your own words when you see _____ stars. Your answer will be correct as long as it ** _____.

Check Page 15.

You may answer in your own words when you see TWO stars. Your answer will be correct as long as it MEANS THE SAME AS THE ONE ON THE CHECK PAGE.

Step 16.

The answer in a space with one star (*) must be * _____ as the * _____.
The answer in a space with two stars (**) should ** _____.

Check Page 16.

The answer in a space with one star (*) must be EXACTLY THE SAME as the ANSWER ON THE CHECK PAGE.
The answer in a space with two stars (**) should MEAN THE SAME AS THE ANSWER ON THE CHECK PAGE.

Step 17.

The answer in a plain space consists of only _____ word. A space with a star (*) means the answer consists of * _____. In either case your answer must be * _____ as the answer given on the * _____.

Check Page 17.

The answer in a plain space consists of only ONE word. A space with a star (*) means the answer consists of MORE THAN ONE WORD. In either case your answer must be EXACTLY THE SAME as the answer given on the CHECK PAGE.

Step 18.

A space with one star means the answer consists of * _____ and it must be * _____ as the answer on the * _____. When you see two stars your answer only has to _____ the _____.

Check Page 18.

A space with one star means the answer consists of MORE THAN ONE WORD and it must be EXACTLY THE SAME as the answer on the CHECK PAGE. When you see two stars your answer only has to MEAN the SAME.

Step 19.

A program makes it easy for you to learn each new idea because the steps are carefully arranged in a particular order or sequence. They build up your knowledge until you can complete a difficult step with little or no help.

Step 20.

You probably cannot complete this step. It is the last step in a sequence and therefore has very little help in it. Scientists describe objects by

*

Check Page 20.

Go on to the next step, which is the first step of the entire sequence.

Step 21.

We can tell an elephant from a lion because they look different. A car and a truck are also easy to tell apart because they look

_____.

Check Page 21.

We can tell an elephant from a lion because they look different. A car and a truck are also easy to tell apart because they look DIFFERENT.

Step 22.

Even with your eyes shut you can tell the difference between a rose and a carnation because they smell _____.

Check Page 22.

Even with your eyes shut you can tell the difference between a rose and a carnation because they smell DIFFERENT.

Step 23.

The sound of a piano and the sound of a trumpet can be told apart because they

*

Check Page 23.

The sound of a piano and the sound of a trumpet can be told apart because they SOUND DIFFERENT.

Step 24.

Look, sound, and smell are characteristics of objects that help us recognize the differences between them. Similarly, height and size are _____ of people that help us recognize the difference between them.

Check Page 24.

Look, sound, and smell are characteristics of objects that help us recognize the differences between them. Similarly, height and size are CHARACTERISTICS of people that help us recognize the difference between them.

Step 25.

The characteristics of an Eskimo are different from the _____ of a Frenchman.

Check Page 25.

The characteristics of an Eskimo are different from the CHARACTERISTICS of a Frenchman.

Step 26.

Each person has his own _____ that make him _____ from everybody else.

Check Page 26.

Each person has his own CHARACTERISTICS that make him DIFFERENT from everybody else.

Step 27.

It is made of leather. It ties with laces. It is worn on the foot. This list describes some characteristics of a _____.

Check Page 27.

It is made of leather. It ties with laces. It is worn on the foot. This list describes some characteristics of a SHOE.

Step 28.

It is frozen. It is made from water.
It is often made in cubes. This list
describes some * _____.

Check Page 28.

It is frozen. It is made from water.
It is often made in cubes. This list
describes some CHARACTERISTICS OF ICE.

Step 29.

List the characteristics of a tangerine,
including its usual color and shape.

**
_____.

Check Page 29.

IT IS ORANGE. IT IS ROUND.
You may have thought of other
characteristics as well.

Step 30.

List the characteristics of the American
flag, including its colors and shape.

**
_____.

Check Page 30.

IT IS RED, WHITE AND BLUE.
IT IS RECTANGULAR. You may have
thought of other characteristics as well.

Step 31.

In science, objects are described by
listing their _____. For
example, scientists would describe
chemicals by _____ their
_____.

Check Page 31.

In science, objects are described by
listing their CHARACTERISTICS. For
example, scientists would describe
chemicals by LISTING their CHARACTERISTICS.

Step 32.

Scientists describe objects by
* _____.

Check Page 32.

Scientists describe objects by LISTING THEIR
CHARACTERISTICS.

Remember? You couldn't answer this step
before. You should have found it easy this
time because of the help the program gave
you in the earlier steps.

PRELIMINARY PROGRAM II*

Instruction Page

In the last booklet you always knew what to write in the blank spaces because the program helped you. The following steps will show you some of the ways in which help is given by a program.

Some of the steps are in two parts, called "A" and "B." First write your answer to the "A" part, and then check your answer by turning to the top half of the next page. Then look down and write your answer to the "B" part. You are allowed to look at the answer to the "A" part while completing the "B" part. Check your answer to the "B" part by turning to the next page.

1A.

First half of the step

Describing the structure of something tells what it is made of or how it is put together.

Bricks and wood make up the structure of a house.

Second half of step

Different kinds of words make up the _____ of a program step.

1A.

Describing the structure of something tells what it is made of or how it is put together.

Bricks and wood make up the structure of a house.

Different kinds of words make up the STRUCTURE of a program step.

1B.

To fill in the blank space above, all you had to do was to copy the word "structure." The structure of the second half of the step was so similar to the _____ of the first half that all you had to do was to find the right word and _____ it in the second half.

1B.

The structure of the second half of the step was so similar to the STRUCTURE of the first half of the step that all you had to do was to find the right word in the first half and COPY it in the second half.

*The broken lines enclose material which appeared on a single page. The format employed here was unusual in that the confirmation was often in view as S responded to the frame which followed.

2A.

First half of step

One way of talking about a chair is to describe its structure.

Second half of step

One way of talking about a program step is to describe its _____.

2A.

One way of talking about a chair is to describe its structure.

One way of talking about a program step is to describe its STRUCTURE.

2B.

You can see again that the structure of the second half of the step above was similar to the _____ of the first half.

You had to look for a word in the first half and then _____ it in the second half.

2B.

You can see again that the structure of the second half of the step was similar to the STRUCTURE of the first half.

You had to look for a word in the first half and then COPY it in the second half.

3A.

In describing the structure of the body, you would tell what it is made of and how it is put together.

In describing the _____ of a program step, you would tell
* _____ and * _____.

3A.

In describing the structure of the body, you would tell what it is made of and how it is put together.

In describing the STRUCTURE of a program step, you would tell
WHAT IT IS MADE OF and HOW IT IS PUT TOGETHER.

3B.

Some words, like "structure," are difficult to spell. When you write words like _____, be sure to _____ them correctly.

3B.

Some words, like "structure," are difficult to spell. When you write words like STRUCTURE, be sure to SPELL them correctly.

4A.

First half of step

When the second half of the step is similar in structure to the first half, you often have to look for a word and _____ it.

Second half of step

This second half of the step is _____ in _____ to the first half.

4A.

When the second half of the step is similar in structure to the first half, you often have to look for a word and COPY it.

This second half of the step is SIMILAR in STRUCTURE to the first half.

4B.

To fill in the blanks in the second half of the step above, all you had to do was copy the words: _____ and _____.

4B.

To fill in the blanks in the second half, all you had to do was copy the words: SIMILAR and STRUCTURE.

5.

One way of knowing that you may have to find a word in the first half of the step and _____ it, is when the second half is _____ in _____ to the * _____.

5.

One way of knowing that you may have to find a word in the first half of the step and COPY it, is when the second half is SIMILAR in STRUCTURE to the FIRST HALF.

6A.

In place of the word "amount," we often see the word "magnitude." When scientists refer to an amount of change in weight, they also use the word "_____."

6A.

In place of the word "amount," we often see the word "magnitude." When scientists refer to an amount of change in weight, they also use the word "MAGNITUDE."

6B.

There are several ways of telling that you may have to look for a word in the first half of the step and _____ it. The word "also" in the example above told you to look for and copy the word _____ from the
* _____ of the step.

6B.

There are several ways of telling that you may have to look for a word in the first half of the step and COPY it. The word "also" in the example above told you to look for and copy the word "MAGNITUDE" in the FIRST HALF of the step.

7.

When you become heavier, you would say your weight has increased in magnitude. When you become taller, you would say your height has _____ in _____.

7.

When you become heavier, you would say your weight has increased in magnitude. When you become taller, you would say your height has INCREASED in MAGNITUDE.

8A.

Bigness is one word we use to indicate an amount. Another word used to indicate an amount is _____.

8A.

Bigness is one word we use to indicate an amount. Another word used to indicate an amount is MAGNITUDE.

8B.

What was your answer? It was _____. The word that told you to write that answer was _____.

8B.

What was your answer? It was MAGNITUDE. The word that told you to write that answer was ANOTHER.

9.

Sometimes you won't be able to copy from the first half of the step. You have to think of the answer yourself, but the program will still help you to fill in the right answer.

The next steps show some of the ways the program can help you.

10A.

Scientists speak of magnitude when measuring the strength of a force. It is easy to feel a push of great magnitude. It is not easy, however, to feel a push of
* _____.

10A.

It is easy to feel a push of great magnitude. It is not easy, however, to feel a push of SMALL, (LESSER, LESS) MAGNITUDE.

10B.

Sometimes your answer means the opposite of a word or idea in the step. In the example above, your answer meant the _____ of the idea in the first half of the step. Instead of great magnitude you therefore wrote
* _____.

10B.

In the example above, your answer meant the OPPOSITE of the idea in the first half of the step. Instead of great magnitude, you therefore wrote SMALL MAGNITUDE.

11A.

Figure A shows two measurements that are unequal in magnitude, but Figure B shows two measurements that are _____ in _____.

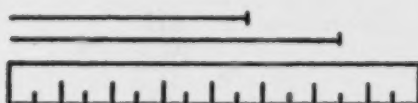


Figure A

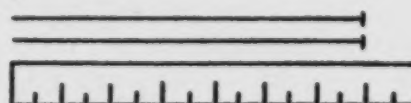


Figure B

11A.

Figure A shows two measurements that are unequal in magnitude, but Figure B shows two measurements that are EQUAL in MAGNITUDE.

11B.

In this example, your answer once again was the _____ of the idea in the first half of the step. Because the lines are the same length, you said the measurements in Figure B are _____ in magnitude.

11B.

In this example, your answer once again was the OPPOSITE of the idea in the first half of the step. Because the lines are the same length, you said the measurements in Figure B are EQUAL in magnitude.

12.

Sometimes your answer may mean the same as an idea in the first half of the step, and sometimes it may mean the _____.

12.

Sometimes your answer may mean the same as an idea in the first half of the step, and sometimes it may mean the OPPOSITE.

13A.

Some steps are like problems. The first half of the step introduces an idea, and you have to complete the idea in the _____ half.

13A.

Some steps are like problems. The first half of the step introduces an idea, and you have to complete the idea in the SECOND half.

13B.

Words like "when," "if" and "since" often introduce an idea in the first half, and you have to complete the idea in the * _____.

13B.

Words like "when," "if" and "since" often introduce an idea in the first half and you have to complete the idea in the SECOND HALF.

14A.

First half of step

When you see this sign (=) between two numbers,

Second half of step

you know that the numbers are _____.

14A.

When you see this sign (=) between two numbers,
you know that the numbers are EQUAL.

14B.

The first half of the step above introduced an idea. You had to complete the
_____ in the second half. The word "when" warned you that you had to
_____ the _____.

14B.

The first half of the step introduced an idea. You had to complete the IDEA
in the second half. The word "when" warned you that you had to COMPLETE the
IDEA.

15A.

First half of step

If you see the (=) sign between two numbers,

Second half of step

you know that the numbers on each side are _____.

15A.

If you see the (=) sign between two numbers, you know that the numbers on each
side are EQUAL.

15B.

In this step the word "if" warned you that you had to _____ and _____.

15B.

In this step the word "if" warned you that you had to COMPLETE and IDEA.

16A.

Since Mary is as big as Betty, you could say they are _____ in size.

16A.

Since Mary is as big as Betty, you could say they are EQUAL in size.

16B.

Which word in the first half of the step warned you that you had to complete an idea? _____.

16B.

Which word in the first half of the step warned you that you had to complete an idea? SINCE

17.

By reading each step carefully, you can find out what the step is helping you to do.

Sometimes you copy something from the first half of the step and sometimes words like but and however tell you to write the _____ of something in the first half. Words like since, if, when warn you that you have to _____ an _____.

17.

Sometimes you copy something from the first half of the step and sometimes words like but and however tell you to write the OPPOSITE of something in the first half. Words like since, if, when warn you that you have to COMPLETE an IDEA.

18A.

$$X = 5$$

$$Y = 3$$

$$\text{Therefore } X + Y = \underline{\hspace{2cm}}$$

18A.

$$X = 5$$

$$Y = 3$$

$$\text{Therefore } X + Y = \underline{8}$$

18B.

Often you have to figure out the missing word just as you would figure out a problem.

In the step above, the (+) sign helped you to figure out the problem because it told you that you had to _____ together two numbers.

18B.

In the step above, the (+) sign helped you to figure out the problem because it told you that you had to ADD together two numbers.

19A.

Mary is as heavy as Betty. They are both fourteen years old. You could therefore say that Mary and Betty are equal both in _____ and in _____.

19A.

Mary is as heavy as Betty. They are both fourteen years old. You could therefore say that Mary and Betty are equal both in WEIGHT and in AGE.

19B.

You had to figure out the problem here just as you figured out the _____ in the last step. The word "heavy" helped you to think of the answer _____. The words "fourteen years old" helped you to think of the answer _____.

19B.

You had to figure out the problem here just as you figured out the PROBLEM in the last step. The word "heavy" helped you to think of the answer WEIGHT. The words "fourteen years old" helped you to think of the answer AGE.

20A.

John's car is as big as Peter's. The cars both have 180 horsepower. Thus John's and Peter's cars are both * _____ and * _____.

20A.

John's car is as big as Peter's. The cars both have 180 horsepower. Thus John's and Peter's cars are both EQUAL IN SIZE and EQUAL IN HORSEPOWER.

20B.

This step gave you another problem to solve. The word "big" helped you to think of the answer _____, and the words "180 horsepower" helped you to think of the answer _____.

20B.

This step gave you another problem to solve. The word "big" helped you to think of the answer SIZE, and the words "180 horsepower" helped you to think of the answer HORSEPOWER.

21A.

The distance from Pittsburgh to Los Angeles is long, but the distance from Pittsburgh to Monessen is _____.

21A.

The distance from Pittsburgh to Los Angeles is long, but the distance from Pittsburgh to Monessen is SHORT.

21B.

What did you do to answer the step above? Check off what you think you did.

- ☐ I copied from the first half of the step.
- ☐ I wrote the opposite of the idea in the first half of the step.
- ☐ I completed an idea started in the first half of the step.
- ☐ I figured out the answer like the answer to a problem.

21B.

I wrote the opposite of the idea in the first half of the step.

22A.

Since the distance from Pittsburgh to Greensburg is 30 miles, and the distance from Pittsburgh to Washington, Pennsylvania is 30 miles, the two distances are _____.

22A.

Since the distance from Pittsburgh to Greensburg is 30 miles, and the distance from Pittsburgh to Washington, Pennsylvania is 30 miles, the two distances are EQUAL.

22B.

What did you do to answer this step?

- ☐ I copied from the first half of the step.
 - ☐ I wrote the opposite of the idea in the first half of the step.
 - ☐ I completed an idea started in the first half of the step.
 - ☐ I figured out the answer like the answer to a problem.
-

22B.

I completed an idea started in the first half of the step.

23A.

Magnitude is represented by a number that can be compared with other numbers. The magnitude of horsepower in a car is represented by a _____ that can be _____ with other numbers.

23A.

Magnitude is represented by a number that can be compared with other numbers. The magnitude of horsepower in a car is represented by a NUMBER than can be COMPARED with other numbers.

23B.

What did you do to answer this step?

- ☐ I copied from the first half of the step.
 - ☐ I wrote the opposite of the idea in the first half of the step.
 - ☐ I completed an idea started in the first half of the step.
 - ☐ I figured out the answer like the answer to a problem.
-

23B.

I copied from the first half of the step.

24A.

Henry and Jim both weigh 150 lbs. and are 5 ft. 7 in. tall. Therefore Henry and Jim are _____ in both * _____.

24A.

Henry and Jim both weigh 150 lbs. and are 5 ft. 7 in. tall. Therefore Henry and Jim are EQUAL in both WEIGHT AND HEIGHT.

24B.

What did you do to answer this step?

- _____ I copied from the first half of the step.
 - _____ I wrote the opposite of the idea in the first half of the step.
 - _____ I completed an idea started in the first half of the step.
 - _____ I figured out the answer like the answer to a problem.
-

24B.

I figured out the answer like the answer to a problem.

25A.

To make a program short and more interesting, shortcuts are sometimes taken. The next few steps show you some of the shortcuts. Roundness is one characteristic of an apple. Smoothness and redness are two more _____ of an apple.

25A.

Roundness is one characteristic of an apple. Smoothness and redness are two more CHARACTERISTICS of an apple.

25B.

In this step, the word you looked for in the first half of the step was _____. However, the words "two more" in the second half made you add the letter "S" to your answer.

25B.

In this step, the word you had to look for in the first half of the step was CHARACTERISTIC. However, the words "two more" in the second half made you add the letter "S" to your answer.

26A.

Fierceness is a characteristic of a bear. Softness and playfulness are some _____ of a kitten.

26A.

Fierceness is a characteristic of a bear. Softness and playfulness are some CHARACTERISTICS of a kitten.

26B.

In the step above, the word "some" warned you to add the letter "____" to your answer.

26B.

In the step above, the word "some" warned you to add the letter "s" to your answer.

27.

"Singular" means "only one." "Plural" means "more than one."

The number 1 in front of a space tells you that your answer should be _____.

The number 12 in front of a space would tell you to make your answer _____.

27.

The number 1 in front of a space tells you that your answer should be SINGULAR.

The number 12 in front of a space would tell you to make your answer PLURAL.

28.

The word "some" in front of a space tells you that your answer should be _____.

The word "a" in front of a space tells you that your answer should be _____.

28.

The word "some" in front of a space tells you that your answer should be PLURAL.

The word "a" in front of a space tells you that your answer should be SINGULAR.

29A.

Hardness and roughness are two _____ of a brick.

Shininess is one _____ of a mirror.

29A.

Hardness and roughness are two CHARACTERISTICS of a brick.
Shininess is one CHARACTERISTIC of a mirror.

29B.

The number "two" in front of the first space told you your answer should be _____.
The number "one" in front of the second space told you your answer should be _____.

29B.

The number "two" in front of the first space told you your answer should be PLURAL.
The number "one" in front of the second space told you your answer should be SINGULAR.

30.

In these next few steps be careful in deciding whether your answers should be singular or plural.

"Description" is a scientific word as well as a word used in ordinary speech.
"Characteristic" and "description" are both scientific _____.

30.

"Description" is a scientific word as well as a word used in ordinary speech.
"Characteristic" and "description" are both scientific WORDS.

31.

You have already learned that scientists describe things by making lists of their _____.
A scientist would describe a force by making a _____ of its _____.

31.

You have already learned that scientists describe things by making lists of their CHARACTERISTICS.
A scientist would describe a force by making a LIST of its CHARACTERISTICS.

32.

A word meaning "list of characteristics" is "description." Listing the characteristics of a force is the same as giving a _____ of that force.

32.

A word meaning "list of characteristics" is "description." Listing the characteristics of a force is the same as giving a DESCRIPTION of that force.

33.

The police often use the newspaper to give a _____ of wanted criminals.

33.

The police often use the newspaper to give a DESCRIPTION of wanted criminals.

34.

In telling you about one of the new elements in nature, a scientist would give you a _____ of that _____.

34.

In telling you about one of the new elements in nature, a scientist would give you a DESCRIPTION of that ELEMENT.

35.

Giving a description of something is the same as * _____.

35.

Giving a description of something is the same as MAKING A LIST OF ITS CHARACTERISTICS (LISTING ITS CHARACTERISTICS).

36.

Another shortcut used in programs is to make you change the verb. The following steps give examples of ways in which you may have to * _____.

36.

Another shortcut used in programs is to make you change the verb. The following steps give examples of ways in which you may have to CHANGE THE VERB.

37.

Mary is eating her breakfast now.

Mary ate her breakfast yesterday.

In this step the verbs are underlined. The first half tells about something happening today. The second half tells about something that happened _____. The second half was changed by changing the _____.

37.

The first half tells about something happening now. The second half tells about something that happened YESTERDAY. The second half was changed by changing the VERB.

38A.

Today John is playing at home.

Yesterday he also _____ at home.

Tomorrow he * _____ at home again.

38A.

Today John is playing at home.

Yesterday he also PLAYED at home.

Tomorrow he WILL PLAY at home again.

38B.

Although the step above was like a "copy" step, you had to change your answers by * _____.

38B.

Although the step above was like a "copy" step, you had to change your answers by CHANGING THE VERB.

39.

When the step tells about things happening at different times, you may have to
* _____. Watch out for words warning you that things are
happening at * _____.

39.

When the step tells about things happening at different times, you may have to
CHANGE THE VERB. Watch out for words warning you that things are happening at
DIFFERENT TIMES.

40.

Verbs have to be changed when the program tells of things happening at
* _____.

40.

Verbs have to be changed when the program tells of things happening at
DIFFERENT TIMES.

41.

Sometimes, changing the verb changes the meaning of the sentence, but other times,
changing the verb does _____ change the * _____.

41.

Sometimes, changing the verb changes the meaning of the sentence, but other times,
changing the verb does NOT change the MEANING OF THE SENTENCE.

42A.

The teacher gave Mary a good grade.
Mary was _____ a good grade by the teacher.

42A.

The teacher gave Mary a good grade.
Mary was GIVEN a good grade by the teacher.

42B.

The example above does not look like a "copy" step.
However, you can see that both halves of the step mean the _____.
All you had to do was change the verb from "gave" to "was _____."

42B.

The example above does not look like a "copy" step.
However, you can see that both halves of the step mean the SAME.
All you had to do was change the verb from "gave" to "was GIVEN."

43.

Which of these three sentences mean the same?
Which means something different?

1. John hit Mary.
2. Mary hit John.
3. Mary was hit by John.

Sentences #____ and #____ mean the same.
Sentence #____ means something different.

43.

Sentences #1 and #3 mean the same.
Sentence #2 means something different.

44A.

We describe an illness by listing its characteristics.
An illness * _____ by listing its characteristics.

44A.

We describe an illness by listing its characteristics.
An illness IS DESCRIBED by listing its characteristics.

44B.

Both halves of the step above mean * _____. All you had to do was
to change the _____ from "describe" to "* _____."

44B.

Both halves of the step above mean THE SAME. All you had to do was to change the VERB from "describe" to "IS DESCRIBED."

45A.

Write the second half to this step so that it means the same as the first half even though you change the verb.

First half of step

We describe a metal by listing its characteristics.

Second half of step

** _____.

45A.

First half of step

We describe a metal by listing its characteristics.

Second half of step

A METAL IS DESCRIBED BY LISTING ITS CHARACTERISTICS.

45B.

Even though you changed the verb, the second half of the step * _____ as the * _____.

45B.

Even though you changed the words around, the second half of the step MEANS THE SAME as the FIRST HALF.

46A.

Write the second half to this step so that it means the same as the first half even though you change the verb.

First half of step

A drug is described by scientists by listing its characteristics.

Second half of step

** _____.

46A.

First half of step

A drug is described by scientists by listing its characteristics.

Second half of step

SCIENTISTS DESCRIBE A DRUG BY LISTING ITS CHARACTERISTICS.

46B.

Although you changed the verb, the second half of the step

*

46B.

Although you changed the words around, the second half of the step
MEANS THE SAME AS THE FIRST HALF.

ATOMICS PROGRAM*

1.

All substances are made up of atoms. Gold is one type of substance which is made up of ATOMS.

2.

Substances may be in the form of solids, liquids, or gases but all three are made up of ATOMS.

3.

Not only are solids like gold made up of ATOMS, but liquids and gases are also MADE UP OF ATOMS.

4.

While substances may differ from each other in many ways, they have in common the fact that they are all MADE up of ATOMS.

5.

There are many different substances, but they all have one common characteristic: they are all MADE UP OF ATOMS.

6.

A characteristic common to all substances is THAT THEY ARE (ALL) MADE UP OF ATOMS.

7.

There are different kinds of atoms. Gold is made of one kind of atom but silver is made up of a DIFFERENT kind of atom.

8.

Iron and copper are not made up of the same kind of atom. They are made of DIFFERENT KINDS of atoms.

9.

In nature, there are about 90 DIFFERENT KINDS of atoms.

10.

Atoms are NOT all alike; there are about 90 DIFFERENT KINDS of atoms.

11.

A substance which consists of only one kind of atom is called an element. Gold consists of only one kind of atom; it is called an ELEMENT.

12.

Iron consists of only one kind of atom. Iron may be called an ELEMENT.

13.

Any substance which consists of only ONE kind of ATOM may be called an ELEMENT.

14.

Silver is an element. This means that silver is made up of only ONE KIND of atom.

15.

Iron is an element. Therefore, it is made up of only ONE KIND OF ATOM.

*Subjects made constructed responses for each of the following frames. The frames reproduced here are those which were presented to the subjects as confirmation frames after they had made their own responses. The correct constructed responses appear in capital letters.

16.

Even a small amount of an element contains vast numbers of atoms, but they are all the SAME KIND of atoms.

17.

An element is a substance which IS MADE UP (CONSISTS) OF ONLY ONE KIND OF ATOM.

18.

If you had a sample of 10 different elements, the number of different kinds of atoms in your sample would be 10.

19.

Ten different elements include ten DIFFERENT kinds of atoms. Twenty different elements include twenty DIFFERENT KINDS OF ATOMS.

20.

There are about 90 different elements found in nature. This means that there are about 90 DIFFERENT KINDS OF ATOMS found in nature.

21.

If the elements copper and zinc are mixed together properly, they will combine to form the metal called brass. Brass is NOT an element.

22.

Brass contains atoms of both copper and zinc. Brass is made up of MORE than one KIND of atom.

23.

The elements copper and zinc are each made up of only ONE KIND of atom. On the other hand, brass is made up of MORE THAN ONE KIND OF ATOM (TWO KINDS OF ATOMS).

24.

There are many substances which, like brass, are non-elements. All non-elements are made up of MORE THAN ONE KIND OF ATOM (TWO OR MORE DIFFERENT KINDS OF ATOMS).

25.

While a sample of an element contains only ONE KIND OF ATOM, a sample of a non-element contains MORE THAN ONE KIND OF ATOM (TWO OR MORE DIFFERENT KINDS OF ATOMS).

26.

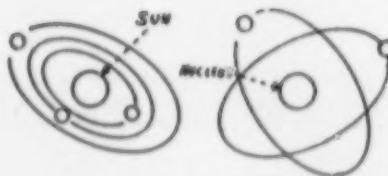
The difference between an element and a non-element is AN ELEMENT IS MADE UP OF ONLY ONE KIND OF ATOM, A NON-ELEMENT OF MORE THAN ONE KIND OF ATOM.

27.

Atoms are sometimes described as looking like our solar system. The center of an atom is called the nucleus (new-klee-us). Just as the center of the solar system is the sun, the center of an atom is the NUCLEUS.

28.

In our solar system, the planets move in paths, called orbits, around the sun. In an atom small particles called electrons move in ORBITS (PATHS) around the NUCLEUS.



29.

An atom consists of a nucleus and one or more electrons. The ELECTRONS move in ORBITS around the NUCLEUS.



30.

Every atom has a nucleus and has ELECTRONS that move in ORBITS AROUND THE NUCLEUS.



31.

The structure of every atom is basically the same; it consists of ELECTRONS AROUND A NUCLEUS (A NUCLEUS WITH ELECTRONS IN ORBITS AROUND THE NUCLEUS).

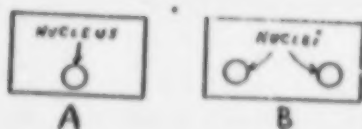


32.

The plural of nucleus is written: nuclei (new-klee-eye). Atomic centers are called NUCLEI.

33.

Figure A shows one NUCLEUS. Figure B shows two NUCLEI.



34.

The word for atomic center is NUCLEUS. The plural is written: NUCLEI.

35.

Each kind of atom has its own nucleus; no two different kinds of atoms have identical NUCLEI.

36.

The nucleus of the hydrogen atom consists of one proton. All other nuclei have more than one PROTON.



37.

The hydrogen atom is easy to diagram since it has a nucleus of only one PROTON.



38.

The hydrogen atom has a nucleus of only ONE PROTON. It also has one ELECTRON in orbit.

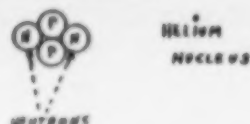


39.

While the hydrogen atom has only one proton in its nucleus, all the other atoms have MORE than one proton in their NUCLEI.

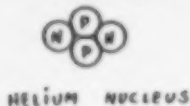
40.

All atomic nuclei, except hydrogen, have particles called neutrons (new-trons) in addition to their protons. The nucleus shown here has two NEUTRONS (PROTONS) and two PROTONS (NEUTRONS).



41.

In addition to protons, most nuclei contain particles called NEUTRONS.



42.

The hydrogen nucleus consists of one proton, but no NEUTRONS. The helium nucleus has two protons and two NEUTRONS.

43.

Atomic nuclei may contain two kinds of particles: PROTONS and NEUTRONS (either order). A third kind of particle, the ELECTRON, orbits around the nucleus.



44.

While all substances are made up of ATOMS, the substances called elements are made up of only ONE KIND of atom.

45.

Gold, silver and iron may all be called ELEMENTS. This means they are each made up of ONLY ONE KIND of atom.

46.

An element is a substance which IS MADE UP OF ONLY ONE KIND OF ATOM.

47.

Each element is given a number, called its atomic number. Hydrogen is given number 1, which is called its ATOMIC NUMBER.

48.

One (1) is the ATOMIC NUMBER of hydrogen. Each element has a different ATOMIC NUMBER.

49.

Elements are given atomic numbers according to the number of protons in their nuclei. Hydrogen has an atomic number of 1, which is the same as the number of PROTONS in its NUCLEUS.



50.

Helium has an atomic number of 2. This means that there are 2 PROTONS in its NUCLEUS.



51.

Hydrogen has atomic number 1; it has ONE proton in its nucleus. Since helium has atomic number 2, we know that it has TWO PROTONS IN ITS NUCLEUS.

52.

Each atom is given a number, called the ATOMIC NUMBER, according to the NUMBER OF PROTONS IN THE NUCLEUS.

53.

An element, such as iron, consists of only one KIND of atom. Every atom of the same element has the same number of PROTONS in its NUCLEUS.

54.

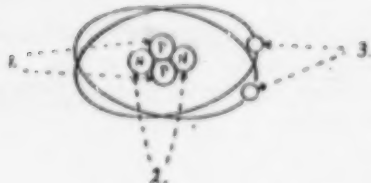
All atoms (except hydrogen) are made up of three kinds of particles. The nucleus contains NEUTRONS (PROTONS) and PROTONS (NEUTRONS). In addition, there are ELECTRONS which travel in orbits.

55.

Label the parts of the helium atom:

1. PROTONS
2. NEUTRONS
3. ELECTRONS

(Parts 1. and 2. make up the NUCLEUS)



56.

Some atomic particles are electrically charged and some are electrically neutral. Those which are not charged are electrically NEUTRAL.

57.

A particle which has no charge is called neutral. A neutron has no charge and is called NEUTRAL.

58.

The neutron has NO electrical charge. It gets its name, neutron, from the fact that it is electrically NEUTRAL.

59.

The electrically neutral particles in atoms are called NEUTRONS. They are said to be neutral because they do NOT have any charge.

60.

As its name suggests, the NEUTRON is an electrically NEUTRAL particle. This means that it does NOT have any charge at all.

61.

The proton has a positive charge. The symbol, (+), is often used to indicate a POSITIVE charge.

62.

The (+) sign stands for a POSITIVE charge. It is often used to label protons because they have a POSITIVE CHARGE.

63.

The particles which have a positive (+) charge are the PROTONS.

64.

The particles with a +, or POSITIVE, charge are called PROTONS.

65.

While neutrons are electrically NEUTRAL, protons have a POSITIVE CHARGE.

NEUTRONS - NEUTRAL

PROTONS - POSITIVE

66.

Describe the electrical property of each of the following:

neutron - NEUTRAL (NO CHARGE).

proton - HAS A POSITIVE CHARGE.

67.

Electrons have a negative charge. The symbol, (-), is often used with ELECTRONS to indicate that they have a NEGATIVE CHARGE.

68.

The orbiting particles in the atom, called ELECTRONS, have a NEGATIVE CHARGE.

69.

Neutrons are electrically NEUTRAL, protons have a POSITIVE charge and electrons have a NEGATIVE CHARGE.

70.

Indicate the electrical property of each of the following:

proton - HAS A POSITIVE CHARGE.

neutron - IS (ELECTRICALLY) NEUTRAL (HAS NO CHARGE).

electron- HAS A NEGATIVE CHARGE.

71.

Electrons are particles which TRAVEL (MOVE) in ORBITS (paths) around the nucleus. Electrons have a NEGATIVE electrical CHARGE.

72.

We know two facts about the electron:

1. Electrons have a NEGATIVE (ELECTRICAL) CHARGE.
2. Electrons TRAVEL IN ORBITS around the nucleus.

73.

Two facts we know about the electron are:

1. THEY ARE NEGATIVELY CHARGED.
2. THEY TRAVEL IN ORBITS AROUND THE NUCLEUS.

EITHER
ORDER

74.

The neutron has no charge; it is electrically NEUTRAL. Neutrons are found in the NUCLEUS of nearly every atom.

75.

Neutrons are particles which:

1. Are electrically NEUTRAL (NOT CHARGED).
2. Are found IN THE NUCLEI OF ATOMS (EXCEPT HYDROGEN).

76.

The two things we have learned about neutrons are:

1. THEY ARE ELECTRICALLY NEUTRAL.
2. THEY ARE FOUND IN THE NUCLEI OF ALL BUT THE HYDROGEN ATOM.

EITHER
ORDER

77.

Protons are POSITIVELY charged particles found in the NUCLEUS of every atom. The number of protons determines the ATOMIC NUMBER of the atom.

78.

Protons are particles which:

1. Have a POSITIVE CHARGE.
2. Are found in THE NUCLEUS OF EVERY ATOM.
3. Determine an atom's ATOMIC NUMBER.

79.

The three things we have learned about protons are:

1. THEY HAVE A POSITIVE CHARGE.
2. THEY ARE FOUND IN THE NUCLEUS.
3. THEY DETERMINE AN ATOM'S ATOMIC NUMBER.

ANY
ORDER

80.

Protons, neutrons and electrons, in various combinations, form all the atoms. All substances are made up of ATOMS.

81.

There are many different substances, but they have one thing in common: they are all MADE up of ATOMS.

82.

A characteristic common to all substances is THEY ARE (ALL) MADE UP OF ATOMS.

83.

Substances made up of only one kind of atom like iron, silver and gold are called ELEMENTS.

84.

An element is a substance which IS MADE UP OF ONLY ONE KIND OF ATOM.

85.

Each different element is made up of a DIFFERENT KIND of atom.

86.

There are about 90 different natural elements. Thus there are about 90 different KINDS OF ATOMS in nature.

87.

The 90 different kinds of atoms combine to form thousands of different substances. Brass, for example, is a combination of two (DIFFERENT) KINDS OF ATOMS.

88.

Brass is NOT an element because it contains MORE THAN ONE KIND OF ATOM.

89.

Iron is an element, but steel is a non-element. Iron contains only ONE KIND OF ATOM, but steel contains MORE THAN ONE KIND OF ATOM.

90.

The hydrogen atom has an atomic number of ONE (1).

91.

Each atom is assigned a different ATOMIC number. It is assigned according to THE NUMBER OF PROTONS IN THE NUCLEUS.

92.

The iron atom has an atomic number of 26. This means that there are 26 protons in its NUCLEUS.

93.

Since helium has atomic number 2, we know that its nucleus contains TWO PROTONS.

94.

The uranium atom has atomic number 92. Thus, the nucleus of uranium CONTAINS 92 PROTONS.

95.

The hydrogen atom has one proton, with a positive charge, and one ELECTRON, with a NEGATIVE charge. It is the only atom which doesn't have any NEUTRONS.



FORCE PROGRAM*

1.

When you push an object, we say you're applying a FORCE to it. So, if you pushed a button, we would say you're applying a FORCE to it.

2.

When people push a stalled car, they are applying a FORCE to it. When a mother pushes a baby carriage, she is also APPLYING a FORCE to it.

3.

A stalled car will move if we push it or pull it. In either case, the car moves because we are APPLYING a FORCE to it.

4.

By pushing or pulling a wagon we can get it to move because we are APPLYING A FORCE to the wagon.

5.

To move a stalled car you might get behind and PUSH the car, or get in front and use a rope to PULL it. In either case, the car will move because you are APPLYING A FORCE to it.

6.

To get objects to move we must APPLY A FORCE TO THEM (PUSH OR PULL THEM).

7.

Pushes and pulls are two ways in which you can APPLY a FORCE to objects and get them to MOVE.

8.

To move a resting object you must either PUSH (PULL) it or PULL (PUSH) it. Either way, to move the object, you must APPLY A FORCE TO IT.

9.

When an object is not moving, we say it is at rest. When a truck is parked we say it is AT REST.

10.

A book which is lying still on a table and a baseball which is lying in the grass are both AT REST.

11.

A flying plane, a rolling ball, and a speeding car are all MOVING objects.

12.

When a car is not moving, it is AT REST. Objects must be either MOVING or AT REST.

13.

All objects must be either AT REST OR MOVING.

14.

A resting object will start to MOVE if we APPLY A FORCE to it.

15.

When you kick a football, it will start to MOVE because you are APPLYING A FORCE to it.

*Subjects made constructed responses for each of the following frames. The frames reproduced here are those which were presented to the subjects as confirmation frames after they had made their own responses. The correct constructed responses appear in capital letters.

16.
If no force is applied to an object at rest, it will remain AT REST.
17.
If a book is at rest and no force is applied to it, the book will REMAIN AT REST.
18.
If an object is at rest and we do not APPLY A FORCE TO IT, it will REMAIN AT REST. However, the object will START TO MOVE if we APPLY A FORCE TO IT.
19.
Forces have only two characteristics:
(1) strength (how strong they are) and
(2) direction (which way they act). The strength of forces tells how STRONG they are.
20.
Some forces are stronger than others. A force of 30 lbs. is STRONGER than a force of 10 lbs.
21.
Car A is pushed with a force of 200 lbs., car B with a force of 15 lbs. The car more likely to move is car A, because the force applied to it is STRONGER.
22.
An automobile pushed with a force of 25 lbs. may not MOVE. If we use a force of 250 lbs., it will probably MOVE because the 250 lb. force is STRONGER.
23.
A force of 1000 POUNDS (LBS.) is very strong. The strength of force is measured in POUNDS (LBS.).
24.
The strength of a force is measured in POUNDS. If you know the number of pounds, you can describe the STRENGTH of a force.
25.
One characteristic of a force is its STRENGTH. This is measured in POUNDS.
26.
Every force acts in some direction. Some forces act in an upward direction. Some forces act in a downward DIRECTION.
27.
In basketball, the object of the game is to shoot (push) the ball so that it moves in the DIRECTION of the basket.
28.
To get the ball into the basket, the ball must be pushed in the right DIRECTION with a force which is STRONG enough.
29.
If the ball goes off to the side of the basket you know that the force you applied was in the WRONG DIRECTION.
30.
If the ball falls short of the basket, you know that the force you applied was NOT STRONG ENOUGH.
31.
The two characteristics of a force are:
(1) its STRENGTH (measured in pounds) and
(2) the DIRECTION in which it acts.

32.

Forces can be represented by arrows. The point of the arrow shows the direction. The force below is acting toward the RIGHT with a strength of 100 LBS.



33.

The arrow below represents a force with a strength of 80 LBS. The direction in which it is acting is toward the LEFT.



34.

The ball in this picture is being pushed in an UPWARD direction with a force of 10 LBS.



35.

The object in this picture is being pulled in a DOWNWARD direction with a force of 2 LBS.



36.

To completely describe a force you must tell its STRENGTH and the DIRECTION in which it acts.

37.

To describe a force completely you must tell both: ITS STRENGTH (HOW STRONG IT IS) AND DIRECTION.

38.

Sometimes an object can be acted on by more than one force. The box below is acted on by TWO forces. It will start moving toward the RIGHT.



39.

These two forces act in the same direction:

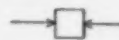


The forces shown below also act in the SAME direction.



40.

These forces act in opposite directions:

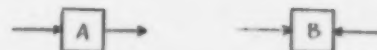


The forces shown below also act in OPPOSITE directions.



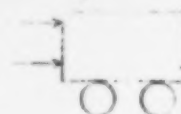
41.

The forces on object A are acting in the same direction, but those on object B are acting in OPPOSITE DIRECTIONS.



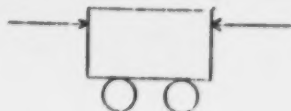
42.

If two people push a wagon in the same direction the wagon will start to MOVE.



43.

The forces shown below are acting in OPPOSITE directions. When two people push a wagon like this it may NOT start to move.



44.

When two people push a wagon, it will NOT start to move if the force in one direction is balanced by the force acting in the OPPOSITE direction.



45.

A force acting in one direction can be balanced by a force acting in the OPPOSITE DIRECTION. When this happens, objects do NOT start to MOVE.

46.

To be called balanced, the forces must act on an object in opposite directions. The forces in the picture are called BALANCED forces.



47.

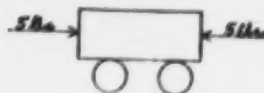
A force acting in one direction can be BALANCED by a force acting in the OPPOSITE DIRECTION.

48.

In addition to acting in opposite directions, two forces must be just as strong as one another in order to be called BALANCED forces.

49.

When one force is equal in strength and acts in the opposite direction of another force, we can say that the forces are BALANCED. This wagon will remain AT REST.



50.

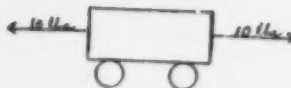
Balanced forces act in OPPOSITE directions and with EQUAL strength. They allow resting objects to REMAIN AT REST.

51.

The two characteristics of forces are strength and direction. Balanced forces act in opposite DIRECTIONS and with equal STRENGTH.

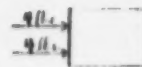
52.

The pulling forces below are balanced because they act in OPPOSITE DIRECTIONS and with EQUAL STRENGTH. The wagon will REMAIN AT REST.



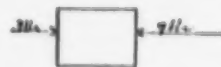
53.

Even though the forces shown below are equal in strength, they are unbalanced because they are not acting in OPPOSITE DIRECTIONS.



54.

The forces shown here are acting in opposite directions, but they are unbalanced because they are not EQUAL IN STRENGTH.

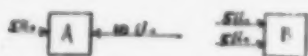


55.

Whenever two forces act on the same object, the forces must be either balanced or UNBALANCED.

56.

The forces acting on object A are UNBALANCED. The forces acting on object B are also UNBALANCED.



57.

The forces acting on this object may be called BALANCED forces. The object will REMAIN AT REST.



58.

The forces acting on this object are called UNBALANCED forces. The object will START TO MOVE.



59.

When balanced forces act on resting objects, the objects REMAIN AT REST. When unbalanced forces act on resting objects, THE OBJECTS START TO MOVE.

60.

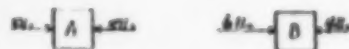
If no force at all acts on a resting object, the object will REMAIN AT REST. The same thing will happen if BALANCED forces act on it.

61.

Balanced forces have the same effect on resting object as NO force at all. In either case, the objects will REMAIN AT REST.

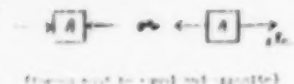
62.

Object A will not start to move because BALANCED FORCES ARE ACTING ON IT. Object B will start to move because UNBALANCED FORCES ARE ACTING ON IT.

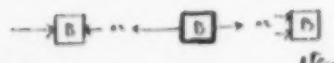


63.

Draw in arrows showing two balanced forces acting on object A. Draw in arrows showing two unbalanced forces acting on object B. Indicate how strong each of the forces is.



(forces must be equal and opposite)



(forces must not be equal and opposite)

64.

Gravity is a force which pulls all objects down. Objects fall because they are PULLED down by the force of GRAVITY.

65.

If you open your fingers, your pencil will fall because it is PULLED down by the force of GRAVITY. When a book falls to the floor, it is being PULLED DOWN by the FORCE OF GRAVITY.

66.

Objects fall because they are PULLED DOWN BY THE FORCE OF GRAVITY.

67.

The strength of all forces is measured in pounds. Since gravity is a FORCE, its strength is also measured in POUNDS.

68.

All objects are pulled DOWN by the FORCE OF GRAVITY and the strength of the pull is measured in POUNDS.

69.

To measure with how much force GRAVITY is pulling you down, all you have to do is step on a scale and WEIGH yourself.

70.

A man weighs 150 lbs.; this means that he is pulled down by GRAVITY with a force of 150 LBS.

71.

The weight of an object is determined by the force of gravity which pulls it down. For example, the WEIGHT of your body is determined by the FORCE OF GRAVITY WHICH PULLS IT DOWN.

72.

The weight of all objects is determined by THE FORCE OF GRAVITY WHICH PULLS THEM DOWN.

73.

The weight of an object and the force of gravity which pulls it down are EQUAL.

74.

The force of gravity pulling a plate down is equal to the weight of the plate. Similarly, the force of gravity pulling a sack down is equal to the WEIGHT OF THE SACK.

75.

The force of gravity pulling any object down determines (and is equal to) the WEIGHT OF THE OBJECT.

76.

The force of gravity pulling on objects is EQUAL to THE WEIGHT OF THE OBJECTS.

77.

The force of gravity is always pulling on objects whether they are at rest or moving. Your body is ALWAYS being pulled down by the force of gravity whether you are at rest or MOVING.

78.

The force of gravity is ALWAYS pulling objects downward.

79.

Gravity ALWAYS pulls objects in a downward direction whether they are at REST or MOVING (FALLING).

80.

The force of gravity pulls on falling objects. It also pulls on objects which are NOT falling.

81.

Whether a ball is lying in the grass, flying upward into the air, or falling to the ground, the force of gravity is ALWAYS pulling it in a DOWNWARD direction.

82.

Whether a brick is rising into the air, falling to the floor or lying on the floor, the force of gravity is ALWAYS PULLING IT DOWN.

83.

A brick lying on a board will remain at rest if it is acted upon by balanced FORCES.

84.

If balanced forces act on a resting object, the object will REMAIN AT REST. If the forces are unbalanced, the object will START TO MOVE.

85.

Whenever you see a resting object you know that the forces acting on it can be called BALANCED forces. Whenever you see an object start to move you know that the forces ACTING ON IT ARE UNBALANCED.

86.

If a book is at rest on a table, you know that it is being acted upon by BALANCED FORCES.

87.

Two forces may be called balanced if they are of EQUAL strength and act in OPPOSITE directions.

88.

The two forces acting on a resting book are balanced. This means that they are:

- | | |
|-----------------------------------|-------------------|
| 1. <u>EQUAL IN STRENGTH</u> and | } EITHER
ORDER |
| 2. <u>OPPOSITE IN DIRECTION</u> . | |

89.

One of the forces which acts on a resting book is the pull of GRAVITY. It acts in a DOWNWARD direction.

90.

Books lying on a table are at rest even though gravity IS ALWAYS PULLING THEM DOWN.

91.

An object remains at rest when the force of gravity, acting in a downward direction, is balanced by a force which acts in an UPWARD direction.

92.

To allow a book to remain at rest, the downward pull of gravity must be balanced by another force which pushes it UPWARD.

93.

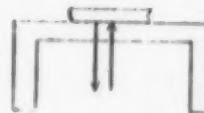
While the force of gravity pulls a resting book down, there must be another force which PUSHES THE BOOK UP.

94.

An object held in your hand remains at rest. While gravity PULLS it down, your hand PUSHES it up.

95.

When a book is at rest on a desk, gravity pulls it in a DOWNWARD direction. The desk PUSHES the book in an upward direction allowing it to remain AT REST.



96.

A book remains at rest on the table despite the downward pull of gravity because the table PUSHES IT UPWARD.

97.

The upward push by the table must be equal to the PULL OF GRAVITY and be acting in the OPPOSITE direction.

98.

A plate resting on a table remains at rest as long as the DOWNWARD pull of gravity and the UPWARD push of the table are of EQUAL strength.

99.

The figure shows a 10-lb. book resting on a table. The book is being PULLED DOWN by gravity with a force of 10 lbs. At the same time, the table is PUSHING (THE BOOK) UP with a force of 10 LBS.



100.

A book resting on the surface of a table is acted upon by at least TWO forces. One is the downward PULL OF (THE FORCE OF) GRAVITY. The other force is the upward PUSH OF THE TABLE (SURFACE).

101.

Whenever an object is at rest on a surface, you know that at least two balanced forces are acting on the object. List the two forces:

1. THE DOWNWARD PULL OF (THE FORCE OF) GRAVITY and
2. THE UPWARD PUSH OF THE SURFACE.

102.

The two forces which act upon objects at rest on a surface may be called BALANCED forces. This means that they are acting in OPPOSITE DIRECTIONS and are of EQUAL STRENGTH.

103.

In this picture, a ball is resting on a stool. Describe the forces which are acting on the ball:

THE FORCE OF GRAVITY IS PULLING DOWN WHILE THE STOOL PUSHES UP. (THESE FORCES ARE EQUAL AND OPPOSITE [BALANCED]).



ATOMICS TEST (PARTS I & II)

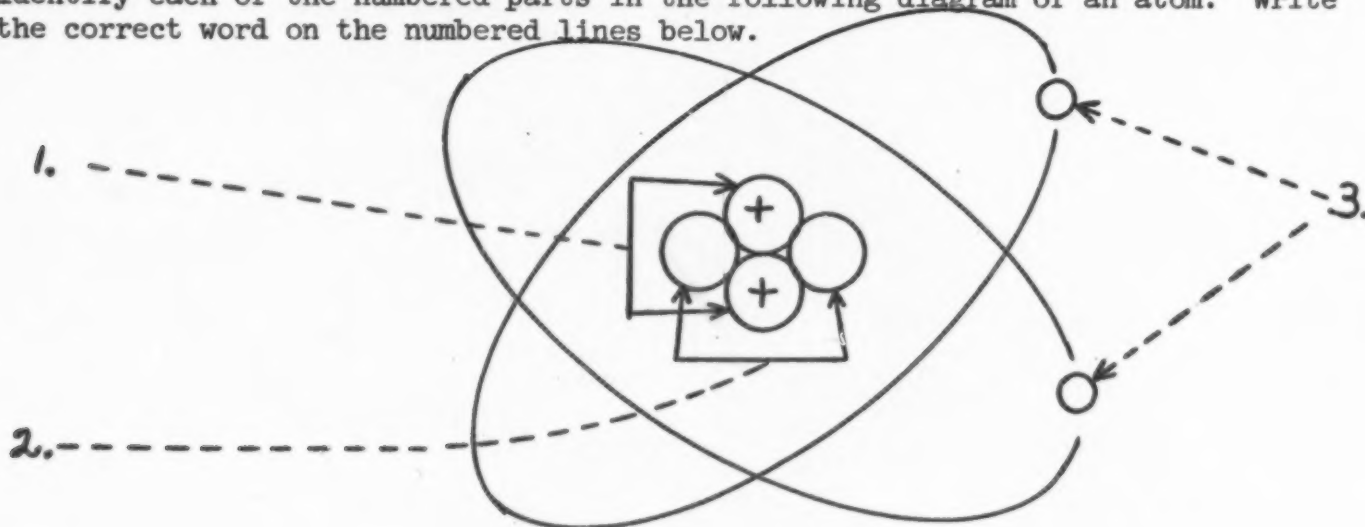
Part I

Complete each of the following by filling in the necessary word(s).

1. An element, in physics and chemistry, is defined as a substance which

_____.
2. The chlorine atom is assigned number 17. Therefore, the nucleus of this atom
_____.
3. What is the difference between an element and a non-element?

_____.
4. A characteristic (of their make-up) which all substances have in common is
_____.
5. Each atom is given a number, called its _____. This
number is assigned according to _____.
6. The number of different elements is about _____. In other words,
the number of different natural _____ is about _____.
7. Identify each of the numbered parts in the following diagram of an atom. Write
the correct word on the numbered lines below.



1. _____
2. _____
3. _____

1. and 2., together, form the _____.

Atomics Test - Part II

1. The hydrogen atom has _____ proton(s), _____ electron(s), and _____ neutron(s).
2. Indicate whether each of the following particles has a charge and, if so, what kind of charge.
 - A. Proton - _____.
 - B. Neutron - _____.
 - C. Electron - _____.
3. Indicate the location, in the atom, of each of the following particles.
 - A. Proton - _____.
 - B. Neutron - _____.
 - C. Electron - _____.

FORCE TEST

Complete each of the following by filling in the necessary words.

1. What happens to a resting object when balanced forces act on it?

2. A single force may be one of two types; it may be a _____ or a _____.
3. The two characteristics of every force are its 1. _____ and
2. _____.
4. An object's weight is determined by _____
_____.
5. In order to be balanced, two forces must be 1. _____ and
2. _____.
6. What happens to a resting object when unbalanced forces act on it?
7. Forces are measured in _____ (units).
8. There is only one way to start an object to move: you must _____
_____ to it.
9. If you see an automobile start to roll away from the curb, you know that it is
being acted upon by _____ forces.

A parked automobile is acted upon by _____ forces.

Force Test - continued

10. For each of the following, write YES if the object is being acted upon by gravity. If it is not, write NO.

A ball, rising into the air. _____

A stone, held in the hand. _____

11. A rock is lying still on a wagon. Indicate whether each of the following is true or false by circling the proper letter.

T F The wagon is pushing up on the rock.

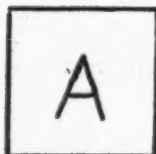
T F The rock is being acted upon by balanced forces.

T F The rock is being acted on by equal and opposite forces.

12. Draw a pair of unbalanced forces acting upon object A.

Draw a pair of balanced forces acting upon object B.

Be sure to label all the forces completely.



APPENDIX B

Results of the Matching of Subjects
Across Conditions

TABLE 1-B
Summary Results for the Matching of $\bar{S}_s$
by IQ, Errors, and Pretest
in the Analysis of Work Rate on the FORCE Program
N = 10⁴

Levels of Independent Variables	MATCHING VARIABLES					
	IQ (Otis Group)		Errors ¹ (Raw Score)		Pretest (Percentage Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>116.02</u>	2.55	23.58	12.35	25.85	8.80
Low IQ	<u>104.88</u>	4.20	23.79	12.32	26.08	8.21
High Errors	110.31	6.59	<u>34.00</u>	8.10	25.92	8.62
Low Errors	110.60	6.63	<u>13.37</u>	4.64	26.00	8.40
High Pretest	110.54	6.47	23.48	12.52	<u>32.92</u>	5.29
Low Pretest	110.37	6.74	23.88	12.14	<u>19.00</u>	4.26
Overall	110.45	6.58	23.68	12.27	25.96	8.47

¹Total number of responses (errors possible) was 200

TABLE 2-B
Summary of the Analysis of Variance:
The Matching of $\bar{S}_s$ for IQ
(used in the analysis of Work Rate in the FORCE program
with IQ, Errors, and Pretest as independent variables)
N = 10⁴

Source	DF	MS	F
A (IQ)	1	3223.47	254.87***
B (Errors)	1	2.16	-
C (Pretest)	1	.78	-
AB	1	.78	-
AC	1	.09	-
BC	1	13.16	1.04
ABC	1	1.16	-
Within Replicates	96	12.65	

***significant beyond the .001 level

TABLE 3-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Log Errors
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Errors, and Pretest as independent variables)
 N = 104

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	.001	-
B (Errors)	1	4.694	208.80***
C (Pretest)	1	.007	-
AB	1	.000	-
AC	1	.000	-
BC	1	.003	-
ABC	1	.001	-
Within Replicates	96	.022	

***significant beyond the .001 level

TABLE 4-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Pretest
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Errors, and Pretest as independent variables)
 N = 104

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	1.38	-
B (Errors)	1	.15	-
C (Pretest)	1	5040.15	208.67***
AB	1	18.62	-
AC	1	7.54	-
BC	1	3.85	-
ABC	1	1.38	-
Within Replicates	96	24.15	

***significant beyond the .001 level

TABLE 5-B

Summary Results for the Matching of Ss
by IQ, Errors, and Pretest
in the Analysis of Work Rate on the ATOMICS Program
N = 104

Levels of Independent Variables	MATCHING VARIABLES					
	IQ (Otis Group)		Errors ¹ (Raw Score)		Pretest (Percentage Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>116.37</u>	3.11	19.62	12.32	24.73	11.41
Low IQ	<u>105.23</u>	4.33	20.27	12.19	24.46	9.98
High Errors	110.56	6.95	<u>29.72</u>	9.00	24.50	10.55
Low Errors	110.04	6.57	<u>10.10</u>	4.68	24.69	10.89
High Pretest	110.56	6.71	20.00	12.13	<u>33.77</u>	6.38
Low Pretest	111.04	6.82	19.88	12.39	<u>15.42</u>	4.18
Overall	110.80	6.74	19.94	12.20	24.60	10.67

¹Total number of responses (errors possible) was 162

TABLE 6-B

Summary of the Analysis of Variance:
The Matching of Ss for IQ
(used in the analysis of Work Rate in the ATOMICS program
with IQ, Errors, and Pretest as independent variables)
N = 104

Source	DF	MS	F
A (IQ)	1	3223.47	217.59***
B (Errors)	1	6.01	-
C (Pretest)	1	6.01	-
AB	1	11.78	-
AC	1	.78	-
BC	1	.78	-
ABC	1	1.62	-
Within Replicates	96	14.82	

***significant beyond the .001 level

TABLE 7-B

Summary of the Analysis of Variance:
 The Matching of Ss for Log Errors
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Errors, and Pretest as independent variables)
 N = 10⁴

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	.028	-
B (Errors)	1	6.996	141.30***
C (Pretest)	1	.004	-
AB	1	.015	-
AC	1	.004	-
BC	1	.006	-
ABC	1	.003	-
Within Replicates	96	.050	

***significant beyond the .001 level

TABLE 8-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Errors, and Pretest as independent variables)
 N = 10⁴

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	1.88	-
B (Errors)	1	.96	-
C (Pretest)	1	8751.11	287.41***
AB	1	8.65	-
AC	1	24.04	-
BC	1	4.65	-
ABC	1	4.65	-
Within Replicates	96	30.45	

***significant beyond the .001 level

TABLE 9-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate, and Errors
in the Analysis of Work Rate in the FORCE Program
N = 80

Levels of Independent Variables	MATCHING VARIABLES							
	IQ		Pretest		Work Rate Atomics (minutes)		Errors ¹ (Raw Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>113.35</u>	2.77	24.80	9.25	47.75	7.56	22.65	12.76
Low IQ	<u>103.53</u>	4.77	23.30	8.73	48.23	6.82	23.50	12.88
High Pretest	108.85	6.10	<u>31.50</u>	5.67	47.98	6.97	23.48	12.47
Low Pretest	108.03	6.51	<u>16.60</u>	4.11	48.00	7.43	22.67	13.16
Fast Work Rate	108.98	6.17	24.20	9.45	<u>42.03</u>	4.45	23.13	13.02
Slow Work Rate	107.90	6.42	23.90	8.57	<u>53.95</u>	3.32	23.03	12.64
High Errors	108.45	6.44	23.50	9.55	47.85	7.87	<u>33.85</u>	8.28
Low Errors	108.43	6.20	24.60	8.42	48.13	6.47	<u>12.30</u>	4.74
Overall	108.44	6.28	24.05	8.97	47.99	7.16	23.08	12.75

¹Total number of errors possible was 200

TABLE 10-B

Summary of the Analysis of Variance:
 The Matching of Ss for IQ
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	1930.61	114.68***
B (Pretest)	1	13.61	-
C (Work Rate (Atomics))	1	23.11	1.37
D (Errors)	1	.01	-
AB	1	.11	-
AC	1	4.51	-
AD	1	1.51	-
BC	1	23.11	1.37
BD	1	6.61	-
CD	1	9.11	-
ABC	1	.31	-
ABD	1	17.11	1.02
ACD	1	9.11	-
BCD	1	.61	-
ABCD	1	.61	-
Within Replicates	64	16.84	

***significant beyond the .001 level

TABLE 11-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	45.00	1.61
B (Pretest)	1	4440.20	158.96***
C (Work Rate (Atomics))	1	1.80	-
D (Errors)	1	24.20	-
AB	1	9.80	-
AC	1	1.80	-
AD	1	.20	-
BC	1	9.80	-
BD	1	5.00	-
CD	1	.20	-
ABC	1	5.00	-
ABD	1	5.00	-
ACD	1	1.80	-
BCD	1	.20	-
ABCD	1	16.20	-
Within Replicates	64	27.90	

***significant beyond the .001 level

TABLE 12-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Work Rate
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	4.51	-
B (Pretest)	1	.01	-
C (Work Rate (Atomics))	1	2844.11	175.20***
D (Errors)	1	1.51	-
AB	1	.01	-
AC	1	19.01	1.17
AD	1	27.61	1.70
BC	1	1.51	-
BD	1	6.61	-
CD	1	23.11	1.42
ABC	1	15.31	-
ABD	1	7.81	-
ACD	1	.61	-
BCD	1	2.81	-
ABCD	1	52.81	3.25
Within Replicates	64	16.24	

***significant beyond the .001 level

TABLE 13-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Errors
 (used in the analysis of Work Rate in the FORCE program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	14.45	-
B (Pretest)	1	12.80	-
C (Work Rate (Atomics))	1	.20	-
D (Errors)	1	9288.05	172.90***
AB	1	12.80	-
AC	1	3.20	-
AD	1	.05	-
BC	1	11.25	-
BD	1	3.20	-
CD	1	1.80	-
ABC	1	18.05	-
ABD	1	5.00	-
ACD	1	9.80	-
BCD	1	18.05	-
ABCD	1	.45	-
Within Replicates	64	53.72	

***significant beyond the .001 level

TABLE 14-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate, and Errors
in the Analysis of Work Rate in the ATOMICS Program
N = 96

Levels of Independent Variables	MATCHING VARIABLES							
	IQ		Pretest		Work Rate (Force) (minutes)		Errors ¹ (Raw Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>115.48</u>	3.40	24.83	11.06	48.35	7.90	20.15	14.44
Low IQ	<u>103.52</u>	4.46	24.92	10.57	48.56	8.68	20.81	13.89
High Pretest	110.00	6.37	<u>34.04</u>	5.75	48.17	8.60	20.75	13.85
Low Pretest	109.00	7.95	<u>15.71</u>	5.41	48.75	7.97	20.21	14.48
Fast Work Rate	109.50	7.10	24.08	9.90	<u>41.79</u>	5.20	20.48	13.91
Slow Work Rate	109.50	7.35	25.67	11.61	<u>55.13</u>	4.46	20.48	14.42
High Errors	109.02	7.46	24.50	10.68	48.21	8.81	<u>31.25</u>	12.34
Low Errors	109.98	6.95	25.25	10.94	48.71	7.73	<u>9.71</u>	3.52
Overall	109.50	7.19	24.88	10.76	48.46	8.25	20.48	14.10

¹Total number of errors possible was 162

TABLE 15-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for IQ
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	3432.04	210.73***
B (Pretest)	1	24.00	1.47
C (Work Rate - Force)	1	.00	-
D (Errors)	1	22.04	1.35
AB	1	51.04	3.13
AC	1	1.04	-
AD	1	20.17	1.24
BC	1	6.00	-
BD	1	7.00	-
CD	1	2.04	-
ABC	1	12.04	-
ABD	1	1.50	-
ACD	1	.17	-
BCD	1	18.37	1.13
ABCD	1	8.17	-
Within Replicates	80	16.28	

***significant beyond the .001 level

TABLE 16-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Pretest
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	.16	-
B (Pretest)	1	8066.67	236.21***
C (Work Rate - Force)	1	60.17	1.76
D (Errors)	1	13.50	-
AB	1	6.00	-
AC	1	4.17	-
AD	1	20.17	-
BC	1	32.67	-
BD	1	10.67	-
CD	1	8.17	-
ABC	1	.67	-
ABD	1	10.67	-
ACD	1	8.17	-
BCD	1	.67	-
ABCD	1	24.00	-
Within Replicates	80	34.15	

***significant beyond the .001 level

TABLE 17-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}_s$ for Work Rate
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	1.04	-
B (Pretest)	1	8.17	-
C (Work Rate - Force)	1	4266.67	170.24***
D (Errors)	1	6.00	-
AB	1	.38	-
AC	1	15.04	-
AD	1	9.38	-
BC	1	20.17	-
BD	1	.17	-
CD	1	42.67	1.70
ABC	1	1.04	-
ABD	1	.04	-
ACD	1	92.04	3.67
BCD	1	.67	-
ABCD	1	1.04	-
Within Replicates	80	25.06	

***significant beyond the .001 level

TABLE 18-B

Summary of the Analysis of Variance
 The Matching of $\bar{S}_s$ for Errors
 (used in the analysis of Work Rate in the ATOMICS program
 with IQ, Pretest, Work Rate, and Errors as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	10.67	-
B (Pretest)	1	7.04	-
C (Work Rate - Force)	1	.00	-
D (Errors)	1	11137.04	1165.32***
AB	1	37.50	-
AC	1	12.04	-
AD	1	1.50	-
BC	1	4.16	-
BD	1	.37	-
CD	1	.16	-
ABC	1	12.04	-
ABD	1	.17	-
ACD	1	7.04	-
BCD	1	.17	-
ABCD	1	.37	-
Within Replicates	80	95.57	

***significant beyond the .001 level

TABLE 19-B

Summary Results for the Matching of Ss
by IQ, Pretest and Work Rate
in the Analysis of Errors on the ATOMICS Program
N = 144

Levels of Independent Variables	MATCHING VARIABLES					
	IQ (Otis Group)		Pretest (Percentage Score)		Work Rate (minutes)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>116.68</u>	4.46	27.67	10.69	47.08	7.75
Low IQ	<u>105.50</u>	4.31	26.28	11.02	47.42	7.59
High Pretest	111.56	7.05	<u>36.17</u>	6.09	47.61	7.33
Low Pretest	110.63	7.19	<u>17.78</u>	5.31	46.89	7.98
Fast Work Rate	110.94	7.38	26.72	10.72	<u>41.22</u>	4.54
Slow Work Rate	111.24	6.88	27.22	11.03	<u>53.28</u>	4.83
Overall	111.09	7.11	26.97	10.84	47.25	7.64

TABLE 20-B

Summary of the Analysis of Variance:
 The Matching of Ss for IQ
 (used in the analysis of Errors in the ATOMICS program
 with IQ, Pretest, and Work Rate as independent variables)
 N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	4500.17	230.43***
B (Pretest)	1	31.17	1.60
C (Work Rate)	1	3.06	-
AB	1	7.56	-
AC	1	18.06	-
BC	1	1.17	-
ABC	1	10.56	-
Within Replicates	136	19.53	

***significant beyond the .001 level

TABLE 21-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Errors in the ATOMICS program
 with IQ, Pretest, and Work Rate as independent variables)
 N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A	1	69.44	2.08
B	1	12173.44	364.69***
C	1	9.00	-
AB	1	.11	-
AC	1	2.78	-
BC	1	13.44	-
ABC	1	.11	-
Within Replicates	136	33.38	

***significant beyond the .001 level

TABLE 22-B

Summary of the Analysis of Variance:
The Matching of Ss for Work Rate
(used in the analysis of Errors in the ATOMICS program
with IQ, Pretest, and Work Rate as independent variables)
N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	4.00	-
B (Pretest)	1	18.78	-
C (Work Rate)	1	5232.11	231.36***
AB	1	1.00	-
AC	1	7.11	-
BC	1	16.00	-
ABC	1	.45	-
Within Replicates	136	22.61	

***significant beyond the .001 level

TABLE 23-B

Summary Results for the Matching of Ss
by IQ, Pretest, and Work Rate
in the Analysis of Errors in the FORCE Program

Levels of Independent Variables	MATCHING VARIABLES					
	IQ (Otis Group)		Pretest (Percentage Score)		Work Rate (minutes)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>118.10</u>	3.95	25.88	10.69	48.19	8.08
Low IQ	<u>103.12</u>	5.07	25.47	10.48	48.28	8.02
Low Pretest	110.44	8.98	<u>16.88</u>	4.98	48.24	8.13
High Pretest	110.85	8.57	<u>34.47</u>	6.52	48.24	7.97
Fast Work Rate	110.72	9.00	25.76	10.54	<u>41.66</u>	4.88
Slow Work Rate	110.57	8.55	25.59	10.64	<u>54.81</u>	4.26
Overall	110.65	8.75	25.68	10.55	48.24	8.02

TABLE 24-B

Summary of the Analysis of Variance:
 The Matching of Ss for IQ
 (used in the analysis of Errors in the FORCE program
 with IQ, Pretest and Work Rate as independent variables)
 N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	7560.26	351.34***
B (Pretest)	1	5.76	-
C (Work Rate)	1	.74	-
AB	1	1.44	-
AC	1	5.76	-
BC	1	.26	-
ABC	1	.47	-
Within Replicates	128	21.52	

***significant beyond the .001 level

TABLE 25-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Errors in the FORCE program
 with IQ, Pretest, and Work Rate as independent variables)
 N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	5.76	-
B (Pretest)	1	10517.76	299.40***
C (Work Rate)	1	1.06	-
AB	1	.12	-
AC	1	2.94	-
BC	1	1.06	-
ABC	1	.12	-
Within Replicates	128	35.13	

***significant beyond the .001 level

TABLE 26-B

Summary of the Analysis of Variance:
 The Matching of Ss for Work Rate
 (used in the analysis of Errors in the FORCE program
 with IQ, Pretest, and Work Rate as independent variables)
 N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	.26	-
B (Pretest)	1	.00	-
C (Work Rate)	1	5876.74	268.36**
AB	1	.03	-
AC	1	.12	-
BC	1	2.38	-
ABC	1	1.88	-
Within Replicates	128	21.90	

***significant beyond the .001 level

TABLE 27-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate and Errors (on another program)
in the Analysis of Errors on the ATOMICS Program
N = 80

Levels of Independent Variables	MATCHING VARIABLES							
	IQ (Otis Group)		Pretest (Percentage Score)		Work Rate (minutes)		Errors ¹ Force (Raw Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>113.35</u>	2.77	24.80	9.25	47.75	7.56	22.65	12.76
Low IQ	<u>103.52</u>	4.77	23.30	8.73	48.23	6.82	23.50	12.88
High Pretest	108.85	6.10	<u>31.50</u>	5.67	47.98	6.97	23.48	12.47
Low Pretest	108.03	6.51	<u>16.60</u>	4.11	48.00	7.43	22.68	13.16
Fast Work Rate	108.98	6.17	24.20	9.45	<u>42.02</u>	4.45	23.13	13.02
Slow Work Rate	107.90	6.42	23.90	8.57	<u>53.95</u>	3.32	23.03	12.64
High Errors	108.45	6.44	23.50	9.55	47.85	7.87	<u>33.85</u>	8.28
Low Errors	108.43	6.20	24.60	8.43	48.13	6.47	<u>12.30</u>	4.74
Overall	108.44	6.28	24.05	8.97	47.99	7.16	23.08	12.75

¹Total number of responses (errors possible) was 200

TABLE 28-B

Summary of the Analysis of Variance:
 The Matching of Ss for IQ
 (used in the analysis of Errors on the ATOMICS program with
 IQ, Pretest, Work Rate, and Errors (on another program) as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	1930.61	114.68***
B (Pretest)	1	13.61	-
C (Work Rate)	1	23.11	1.37
D (Errors (Force))	1	.01	-
AB	1	.11	-
AC	1	4.51	-
AD	1	1.51	-
BC	1	23.11	1.37
BD	1	6.61	-
CD	1	9.11	-
ABC	1	.31	-
ABD	1	17.11	1.02
ACD	1	9.11	-
BCD	1	.61	-
ABCD	1	.61	-
Within Replicates	64	16.84	

***significant beyond the .001 level

TABLE 29-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Errors on the ATOMICS program with
 IQ, Pretest, Work Rate, and Errors (on another program) as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	45.00	1.61
B (Pretest)	1	4440.20	159.15***
C (Work Rate)	1	1.80	-
D (Errors (Force))	1	24.20	-
AB	1	9.80	-
AC	1	1.80	-
AD	1	.20	-
BC	1	9.80	-
BD	1	5.00	-
CD	1	.20	-
ABC	1	5.00	-
ABD	1	5.00	-
ACD	1	1.80	-
BCD	1	.20	-
ABCD	1	16.20	-
Within Replicates	64	27.90	

***significant beyond the .001 level

TABLE 30-B

Summary of the Analysis of Variance:
 The Matching of S_s for Work Rate
 (used in the analysis of Errors on the ATOMICS program with
 IQ, Pretest, Work Rate and Errors (on another program) as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	4.51	-
B (Pretest)	1	.01	-
C (Work Rate)	1	2844.11	175.20***
D (Errors (Force))	1	1.51	-
AB	1	.01	-
AC	1	19.01	1.17
AD	1	27.61	1.70
BC	1	1.51	-
BD	1	6.61	-
CD	1	23.11	1.42
ABC	1	15.31	-
ABD	1	7.81	-
ACD	1	.61	-
BCD	1	2.81	-
ABCD	1	52.81	3.25
Within Replicates	64	16.24	

***significant beyond the .001 level

TABLE 31-B

Summary of the Analysis of Variance:
 The Matching of S_s for Errors
 (used in the analysis of Errors on the ATOMICS program with
 IQ, Pretest, Work Rate and Errors (on another program) as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	14.45	-
B (Pretest)	1	12.80	-
C (Work Rate)	1	.20	-
D (Errors (Force))	1	9288.05	172.89***
AB	1	12.80	-
AC	1	3.20	-
AD	1	.05	-
BC	1	11.25	-
BD	1	3.20	-
CD	1	1.80	-
ABC	1	18.05	-
ABD	1	5.00	-
ACD	1	9.80	-
BCD	1	18.05	-
ABCD	1	.45	-
Within Replicates	64	53.72	

***significant beyond the .001 level

TABLE 32-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate, and Errors (on another program)
in the Analysis of Errors on the FORCE Program
N = 96

Levels of Independent Variables	MATCHING VARIABLES							
	IQ (Otis Group)		Pretest (Percentage Score)		Work Rate (minutes)		Errors ¹ Atomics (Raw Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>115.48</u>	3.40	24.83	11.06	48.35	7.90	20.15	14.44
Low IQ	<u>103.52</u>	4.46	24.92	10.57	48.56	8.68	20.81	13.89
High Pretest	110.00	6.37	<u>34.04</u>	5.75	48.17	8.60	20.75	13.85
Low Pretest	109.00	7.95	<u>15.71</u>	5.41	48.75	7.97	20.21	14.48
Fast Work Rate	109.50	7.10	24.08	9.90	<u>41.72</u>	5.20	20.48	13.91
Slow Work Rate	109.50	7.35	25.67	11.61	<u>55.13</u>	4.46	20.48	14.42
High Errors	109.02	7.46	24.50	10.68	48.21	8.81	<u>31.25</u>	12.34
Low Errors	109.98	6.95	25.25	10.94	48.71	7.73	<u>9.71</u>	3.52
Overall	109.50	7.19	24.88	10.76	48.46	8.25	20.48	14.10

¹Total number of responses (errors possible) was 162

TABLE 33-B

Summary of the Analysis of Variance:
 The Matching of S_s for IQ
 (used in the analysis of Errors on the FORCE program with
 IQ, Pretest, Work Rate and Errors (on another program) as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	3432.04	210.73***
B (Pretest)	1	24.00	1.47
C (Work Rate)	1	.00	-
D (Errors (Atomics))	1	22.04	1.35
AB	1	51.04	3.13
AC	1	1.04	-
AD	1	20.17	1.24
BC	1	6.00	-
BD	1	7.04	-
CD	1	2.04	-
ABC	1	12.04	-
ABD	1	1.50	-
ACD	1	.17	-
BCD	1	18.37	1.13
ABCD	1	8.17	-
Within Replicates	80	16.28	

***significant beyond the .001 level

TABLE 34-B

Summary of the Analysis of Variance:
 The Matching of S_s for Pretest
 (used in the analysis of Errors on the FORCE program with
 IQ, Pretest, Work Rate, and Errors (on another program) as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	.16	-
B (Pretest)	1	8066.67	236.21***
C (Work Rate)	1	60.17	1.76
D (Errors (Atomics))	1	13.50	-
AB	1	6.00	-
AC	1	4.17	-
AD	1	20.17	-
BC	1	32.67	-
BD	1	10.67	-
CD	1	8.17	-
ABC	1	.67	-
ABD	1	10.67	-
ACD	1	8.17	-
BCD	1	.67	-
ABCD	1	24.00	-
Within Replicates	80	34.15	

***significant beyond the .001 level

TABLE 35-B

Summary of the Analysis of Variance:
 The Matching of Ss for Work Rate
 (used in the analysis of Errors on the FORCE program with
 IQ, Pretest, Work Rate and Errors (on another program) as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	1.04	-
B (Pretest)	1	8.17	-
C (Work Rate)	1	4266.67	170.24***
D (Errors (Atomics))	1	6.00	-
AB	1	.38	-
AC	1	15.04	-
AD	1	9.38	-
BC	1	20.17	-
BD	1	.17	-
CD	1	42.67	1.70
ABC	1	1.04	-
ABD	1	.04	-
ACD	1	92.04	3.67
BCD	1	.67	-
ABCD	1	1.04	-
Within Replicates	80	25.07	

***significant beyond the .001 level

TABLE 36-B

Summary of the Analysis of Variance:
 The Matching of Ss for Errors
 (used in the analysis of Errors on the FORCE program with
 IQ, Pretest, Work Rate and Errors (on another program) as independent variables)
 N = 96

Source	DF	MS	F
A (IQ)	1	10.67	-
B (Pretest)	1	7.04	-
C (Work Rate)	1	.00	-
D (Errors (Atomics))	1	11,137.04	116.53***
AB	1	37.50	-
AC	1	12.04	-
AD	1	1.50	-
BC	1	4.17	-
BD	1	.38	-
CD	1	.17	-
ABC	1	12.04	-
ABD	1	.17	-
ACD	1	7.04	-
BCD	1	.17	-
ABCD	1	.37	-
Within Replicates	80	95.57	

***significant beyond the .001 level

TABLE 37-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate and Errors¹
in the Analysis of Posttest Scores on the ATOMICS program
N = 112

Levels of Independent Variables	MATCHING VARIABLES							
	IQ		Pretest		Work Rate		Errors ¹	
	Mean	S.D.	(Otis Group) Mean	(Percentage Score) S.D.	(minutes) Mean	S.D.	(Raw Score) Mean	S.D.
High IQ	<u>115.27</u>	3.12	27.46	16.65	47.13	8.69	19.86	13.98
Low IQ	<u>103.87</u>	4.23	29.42	21.99	47.70	8.07	21.16	13.33
High Pretest	109.96	6.13	<u>35.11</u>	7.02	46.23	7.74	20.79	13.58
Low Pretest	109.18	7.47	<u>21.79</u>	24.96	48.59	8.83	20.23	13.76
Fast Work Rate	109.82	6.74	25.23	15.56	<u>40.80</u>	5.20	20.89	13.72
Slow Work Rate	109.32	6.94	31.66	22.35	<u>54.02</u>	4.98	20.13	13.61
High Errors	<u>109.23</u>	6.87	27.77	19.18	46.86	8.96	<u>31.18</u>	11.16
Low Errors	109.91	6.80	29.13	19.85	47.96	7.73	<u>2.84</u>	4.18
Overall	109.57	6.82	<u>28.45</u>	19.44	47.41	8.35	20.51	<u>13.61</u>

¹The total number of responses (errors possible) was 162

TABLE 38-B

Summary of the Analysis of Variance:
 The Matching of Ss for IQ
 (used in the analysis of Posttest Scores on the ATOMICS program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 112

Source	DF	MS	F
A (IQ)	1	3634.32	248.59***
B (Pretest)	1	17.29	1.18
C (Work Rate)	1	7.00	-
D (Errors)	1	12.89	-
AB	1	30.04	2.05
AC	1	.89	-
AD	1	3.57	-
BC	1	5.14	-
BD	1	8.04	-
CD	1	.89	-
ABC	1	12.89	-
ABD	1	.57	-
ACD	1	5.14	-
BCD	1	12.89	-
ABCD	1	.14	-
Within Replicates	96	14.62	

***significant beyond the .001 level

TABLE 39-B

Summary of the Analysis of Variance:
 The Matching of Ss for Pretest
 (used in the analysis of Posttest Scores on the ATOMICS program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 112

Source	DF	MS	F
A (IQ)	1	108.04	-
B (Pretest)	1	4968.89	140.12***
C (Work Rate)	1	1157.14	3.26
D (Errors)	1	51.57	-
AB	1	170.04	-
AC	1	11.57	-
AD	1	549.14	1.55
BC	1	75.57	-
BD	1	57.14	-
CD	1	180.04	-
ABC	1	28.00	-
ABD	1	195.57	-
ACD	1	43.75	-
BCD	1	258.04	-
ABCD	1	34.32	-
Within Replicates	96	354.70	

***significant beyond the .001 level

TABLE 40-B

Summary of the Analysis of Variance:
 The Matching of Ss for Work Rate
 (used in the analysis of Posttest Scores on the ATOMICS program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 112

Source	DF	MS	F
A (IQ)	1	9.14	-
B (Pretest)	1	155.57	5.97*
C (Work Rate)	1	4889.29	187.75***
D (Errors)	1	34.32	-
AB	1	6.04	-
AC	1	26.04	1.00
AD	1	3.57	-
BC	1	2.89	-
BD	1	.57	-
CD	1	51.57	1.98
ABC	1	14.29	-
ABD	1	.89	-
ACD	1	38.89	1.49
BCD	1	1.75	-
ABCD	1	5.14	-
Within Replicates	96	26.01	

*significant beyond the .05 level

***significant beyond the .001 level

TABLE 41-B

Summary of the Analysis of Variance:
 The Matching of Ss for Errors
 (used in the analysis of Posttest Scores on the ATOMICS program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 112

Source	DF	MS	F
A (IQ)	1	47.58	-
B (Pretest)	1	8.58	-
C (Work Rate)	1	16.51	-
D (Errors)	1	12750.22	161.10***
AB	1	27.01	-
AC	1	18.08	-
AD	1	9.72	-
BC	1	37.72	-
BD	1	3.22	-
CD	1	29.01	-
ABC	1	5.58	-
ABD	1	.01	-
ACD	1	3.94	-
BCD	1	10.94	-
ABCD	1	.43	-
Within Replicates	96	79.14	

***significant beyond the .001 level

TABLE 42-B

Summary Results for the Matching of Ss
by IQ, Pretest, Work Rate and Errors
in the Analysis of Posttest Scores on the FORCE Program
N = 80

Levels of Independent Variables	MATCHING VARIABLES							
	IQ		Pretest		Work Rate		Errors ¹	
	(Otis Group) Mean	S.D.	(Percentage Score) Mean	S.D.	(minutes) Mean	S.D.	(Raw Score) Mean	S.D.
High IQ	<u>113.40</u>	2.89	24.50	9.64	49.33	8.36	22.08	12.49
Low IQ	<u>103.70</u>	4.87	23.50	8.84	49.88	8.67	23.08	13.07
High Pretest	109.10	6.20	<u>31.80</u>	5.43	49.18	8.24	22.70	12.40
Low Pretest	108.00	6.43	<u>16.20</u>	4.15	50.03	8.77	22.45	13.18
Fast Work Rate	108.95	6.14	24.40	9.83	<u>42.60</u>	4.39	22.98	12.92
Slow Work Rate	108.15	6.61	23.60	8.63	<u>56.60</u>	5.04	22.18	12.66
High Errors	108.45	6.48	23.40	9.57	49.88	9.14	<u>33.30</u>	8.21
Low Errors	108.65	6.19	24.60	8.90	<u>49.33</u>	7.84	<u>11.85</u>	4.91
Overall	108.55	6.30	24.00	9.20	49.60	8.47	22.58	12.71

¹The total number of responses (errors possible) was 200

TABLE 43-B

Summary of the Analysis of Variance:
 The Matching of S_s for IQ
 (used in the analysis of Posttest Scores on the FORCE program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	1881.80	107.47***
B (Pretest)	1	24.20	-
C (Work Rate)	1	12.80	-
D (Errors)	1	.80	-
AB	1	.20	-
AC	1	3.20	-
AD	1	3.20	-
BC	1	39.20	2.24
BD	1	5.00	-
CD	1	5.00	-
ABC	1	.00	-
ABD	1	24.20	1.38
ACD	1	5.00	-
BCD	1	3.20	-
ABCD	1	3.20	-
Within Replicates	64	17.51	

***significant beyond the .001 level

TABLE 44-B

Summary of the Analysis of Variance:
 The Matching of S_s for Pretest
 (used in the analysis of Posttest Scores on the FORCE program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	20.00	-
B (Pretest)	1	4867.20	185.77***
C (Work Rate)	1	12.80	-
D (Errors)	1	28.80	1.10
AB	1	20.00	-
AC	1	.80	-
AD	1	.80	-
BC	1	12.80	-
BD	1	.00	-
CD	1	3.20	-
ABC	1	7.20	-
ABD	1	7.20	-
ACD	1	.80	-
BCD	1	28.80	1.10
ABCD	1	.80	-
Within Replicates	64	26.20	

***significant beyond the .001 level

TABLE 45-B

Summary of the Analysis of Variance:
 The Matching of Ss for Work Rate
 (used in the analysis of Posttest Scores on the FORCE program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	6.05	-
B (Pretest)	1	14.45	-
C (Work Rate)	1	3920.00	158.37***
D (Errors)	1	6.05	-
AB	1	.80	-
AC	1	4.05	-
AD	1	16.20	-
BC	1	.05	-
BD	1	.20	-
CD	1	48.05	1.94
ABC	1	3.20	-
ABD	1	2.45	-
ACD	1	.20	-
BCD	1	33.80	1.37
ABCD	1	22.05	-
Within Replicates	64	24.78	

***significant beyond the .001 level

TABLE 46-B

Summary of the Analysis of Variance:
 The Matching of Ss for Errors
 (used in the analysis of Posttest Scores on the FORCE program
 with IQ, Pretest, Work Rate and Errors as independent variables)
 N = 80

Source	DF	MS	F
A (IQ)	1	20.00	-
B (Pretest)	1	1.25	-
C (Work Rate)	1	12.80	-
D (Errors)	1	9202.05	173.23***
AB	1	20.00	-
AC	1	.05	-
AD	1	5.00	-
BC	1	45.00	-
BD	1	8.45	-
CD	1	.80	-
ABC	1	18.05	-
ABD	1	1.80	-
ACD	1	.45	-
BCD	1	9.80	-
ABCD	1	22.05	-
Within Replicates	64	53.12	

***significant beyond the .001 level

TABLE 47-B

Summary Results for the Matching of Ss
by IQ, Pretest and Work Rate
in the Analysis of Errors and Posttest Scores on the ATOMICS Program
N = 144

Levels of Independent Variables	MATCHING VARIABLES				DEPENDENT VARIABLES			
	IQ		Pretest		Work Rate		Errors ¹	
	Mean	S.D.	(Otis Group)	(Percentage Score)	(minutes)	(Raw Score)	(Percentage Score)	(Percentage Score)
High IQ	<u>116.68</u>	4.46	27.67	10.69	47.08	16.07	12.82	84.94
Low IQ	<u>105.50</u>	4.31	26.28	11.02	47.42	25.01	19.10	74.69
High Pretest	111.56	7.05	<u>36.17</u>	6.09	47.61	15.61	13.33	86.61
Low Pretest	110.63	7.19	<u>17.78</u>	5.31	46.89	25.47	18.51	73.03
Fast Work Rate	110.94	7.38	26.72	10.72	<u>41.22</u>	23.33	19.12	77.11
Slow Work Rate	111.24	6.88	27.22	11.03	<u>53.28</u>	17.75	13.73	82.53
Overall	111.09	7.11	117.54	10.84	58.43	20.54	16.82	79.82
					7.64			18.54

¹The total number of responses (errors possible) was 162

TABLE 48-B

Summary of the Analysis of Variance
of Log Errors on the ATOMICS Program
with IQ, Pretest and Work Rate as independent variables
N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	1.50	12.60***
B (Pretest)	1	1.94	16.32***
C (Work Rate)	1	.54	4.52*
AB	1	.35	2.92
AC	1	.13	1.08
BC	1	.07	-
ABC	1	.14	-
Within Replicates	136	.12	

*significant beyond the .05 level

***significant beyond the .001 level

TABLE 49-B

Summary of the Analysis of Variance
of Posttest on the ATOMICS Program
with IQ, Pretest and Work Rate as independent variables
N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	3782.25	14.16***
B (Pretest)	1	6642.25	24.88***
C (Work Rate)	1	1056.25	3.96*
AB	1	354.69	1.33
AC	1	930.25	3.48
BC	1	20.25	-
ABC	1	34.03	-
Within Replicates	136	267.02	

*significant beyond the .05 level

***significant beyond the .001 level

TABLE 50-B

Summary of the Analysis of Variance:

The Matching of Ss for IQ

(used in the analysis of Errors and Posttest Scores on the ATOMICS program with IQ, Pretest and Work Rate as independent variables)

N = 144

Source	DF	MS	F
A (IQ)	1	4500.17	230.42***
B (Pretest)	1	31.17	-
C (Work Rate)	1	3.06	-
AB	1	7.56	-
AC	1	18.06	-
BC	1	1.17	-
ABC	1	10.56	-
Within Replicates	136	19.53	

***significant beyond the .001 level

TABLE 51-B

Summary of the Analysis of Variance:

The Matching of Ss for Pretest

(used in the analysis of Errors and Posttest Scores on the ATOMICS program with IQ, Pretest and Work Rate as independent variables)

N = 144

Source	DF	MS	F
A (IQ)	1	69.44	2.08
B (Pretest)	1	12173.44	364.69***
C (Work Rate)	1	9.00	-
AB	1	.11	-
AC	1	2.78	-
BC	1	13.44	-
ABC	1	.11	-
Within Replicates	136	33.38	

***significant beyond the .001 level

TABLE 52-B

Summary of the Analysis of Variance:
 The Matching of $\bar{S}$ s for Work Rate
 (used in the analysis of Errors and Posttest Scores on the ATOMICS program
 with IQ, Pretest and Work Rate as independent variables)
 N = 144

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	4.00	-
B (Pretest)	1	18.78	-
C (Work Rate)	1	5232.11	231.41***
AB	1	1.00	-
AC	1	7.11	-
BC	1	16.00	-
ABC	1	.45	-
Within Replicates	136	22.61	

***significant beyond the .001 level

TABLE 53-B

Summary Results for the Matching of Ss
by IQ, Pretest and Work Rate
in the Analysis of Errors and Posttest Scores on the FORCE Program
N = 136

Levels of Independent Variables	MATCHING VARIABLES				DEPENDENT VARIABLES					
	IQ (Otis Group)		Pretest (Percentage Score)		Work Rate (minutes)		Errors ¹ (Raw Score)		Posttest (Percentage Score)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High IQ	<u>118.10</u>	3.95	25.88	10.69	48.19	8.08	16.06	11.84	83.35	10.56
Low IQ	<u>103.19</u>	5.07	25.47	10.48	48.28	8.02	32.22	21.58	70.18	19.16
Low Pretest	110.44	8.98	<u>16.88</u>	4.98	48.24	8.13	26.23	20.77	73.24	19.48
High Pretest	110.85	8.57	<u>34.47</u>	6.52	48.24	7.97	22.04	17.27	80.29	12.73
Fast Work Rate	110.72	9.00	25.76	10.54	<u>41.66</u>	4.88	28.48	22.99	74.18	18.17
Slow Work Rate	110.57	8.55	25.59	10.64	<u>54.81</u>	4.26	19.79	13.10	79.35	14.93
Overall	110.65	8.75	25.68	10.55	48.24	8.02	24.14	19.14	76.76	16.77

¹The total number of responses (errors possible) was 200

TABLE 54-B

Summary of the Analysis of Variance
of Log Errors on the FORCE Program
with IQ, Pretest, and Work Rate as independent variables
N = 136

Source	DF	MS	F
A (IQ)	1	3.35	29.75***
B (Pretest)	1	.17	1.53
C (Work Rate)	1	.56	4.93*
AB	1	.04	-
AC	1	.06	-
BC	1	.04	-
ABC	1	.13	1.18
Within Replicates	128	.11	

*significant beyond the .05 level

***significant beyond the .001 level

TABLE 55-B

Summary of the Analysis of Variance
of Posttest on the FORCE Program
with IQ, Pretest, and Work Rate as independent variables
N = 136

Source	DF	MS	F
A (IQ)	1	5903.06	28.06***
B (Pretest)	1	1694.12	8.05**
C (Work Rate)	1	911.06	4.33*
AB (IQ X Pretest)	1	1321.88	6.28*
AC (IQ X Work Rate)	1	870.12	4.14*
BC	1	248.94	1.18
ABC	1	92.23	-
Within Replicates	128	210.37	

*significant beyond the .05 level

**significant beyond the .01 level

***significant beyond the .001 level

TABLE 56-B

Summary of the Analysis of Variance:

The Matching of Ss for IQ

(used in the analysis of Errors and Posttest Scores on the FORCE program with IQ, Pretest and Work Rate as independent variables)

N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	7560.26	351.31***
B (Pretest)	1	5.76	-
C (Work Rate)	1	.74	-
AB	1	1.44	-
AC	1	5.76	-
BC	1	.26	-
ABC	1	.47	-
Within Replicates	128	21.52	

***significant beyond the .001 level

TABLE 57-B

Summary of the Analysis of Variance:

The Matching of Ss for Pretest Scores

(used in the analysis of Errors and Posttest Scores on the FORCE program with IQ, Pretest and Work Rate as independent variables)

N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	5.76	-
B (Pretest)	1	10517.76	229.40***
C (Work Rate)	1	1.06	-
AB	1	.12	-
AC	1	2.94	-
BC	1	1.06	-
ABC	1	.12	-
Within Replicates	128	35.13	

***significant beyond the .001 level

TABLE 58-B

Summary of the Analysis of Variance:
 The Matching of Ss for Work Rate
 (used in the analysis of Errors and Posttest Scores on the FORCE program
 with IQ, Pretest and Work Rate as independent variables)
 N = 136

<u>Source</u>	<u>DF</u>	<u>MS</u>	<u>F</u>
A (IQ)	1	.26	-
B (Pretest)	1	.00	-
C (Work Rate)	1	5876.74	268.36***
AB	1	.03	-
AC	1	.12	-
BC	1	2.38	-
ABC	1	1.88	-
Within Replicates	128	21.90	

***significant beyond the .001 level